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ORIGINAL ARTICLES

Contents

EDITORIALS

RESOLUTION FOR 1939

WITH the start of a new year one cannot help but speculate regarding the prospects for the coming period. What have the next twelve months in store for medicine? Are we in for changes? And along what lines? Who will name them and control them?

To one who has been active in the ranks for over thirty years, a longing fills the heart for the old order of two decades or more ago when the primary thought in the minds of physicians was to care for the sick and advance the science of medicine. Perhaps the world has already moved to the point where change in administration has become inevitable, but we can hope that that primary aim will remain the central governing thought of the medical profession.

At any rate, we must assure ourselves that medicine will remain in the control of the physician. We must not be forced to transfer our professional birthright to politicians, to large foundations or to physicians who have never devoted ten minutes to the actual practice of medicine. We know that we must meet the economic needs of the times, and, after due and deliberate study and discussion, we shall do so. But we must also stand shoulder to shoulder, yielding no infinitesimal part of our heritage, allowing no outsiders to regulate and control our profession.

Are we to have socialized medicine, health insurance, or some form of government control? Are we to turn haphazardly to rapidly brought out schemes? Let the doctors speak, through their representative organizations, to retain for the practicing profession the control of the practice of medicine. A resolution for all of us for 1939—in the words of the Constitution of the American Medical Association—to "promote the science and art of medicine and the betterment of public health."   T. S. W.

HOSPITAL JOURNALS

MOST of us are familiar with certain institutional publications, such as those issued by the staffs of Johns Hopkins, the Mayo Clinic and a few other medical groups. However, for the most part, only the larger centers of medical teaching can afford this practice.

Therefore it was with interest that we received the first issue of the *Brooklyn Hospital Journal*, a quarterly of sixty to seventy pages of well presented information, dressed up nicely in a pigeon blue cover. Scientific articles are contributed by the men on the staff of the hospital, and one historical article appears in each number. The editor, Dr. Nathaniel P. Rathbun, well known to urologists throughout the country, has done a fine job with the seven papers of the introductory number. The printing is likewise excellent.

Congratulations to editor, contributors and staff! This is a move in the right direction, a practice that should be copied by other hospital groups throughout the land.

T. S. W.

ESSAY AWARD

THE Mississippi Valley Medical Society offers a cash prize of $100.00, a gold medal and a certificate for the best unpublished essay on a subject of interest and practical value to the general practitioner. Entrants must be members of the American Medical Association. Contributions must be not over 5,000 words in length, must be typewritten in English, and must be submitted in quintuplicate not later than May 1, 1939.

The winner will be invited to present his paper before the next annual meeting of the Mississippi Valley Medical Society at Burlington, Iowa, September 27–29, 1939. The Society reserves the exclusive right to publish the essay first in its official publication.

Further information may be secured from Harold Swanberg, M.D., Secretary, Mississippi Valley Medical Society, 209 W.C.U. Building, Quincy Illinois.

THE ASSOCIATION OF POLYCYSTIC DISEASE OF THE KIDNEYS WITH CONGENITAL ANEURYSMS OF THE CEREBRAL ARTERIES*

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POLYCYSTIC disease of the kidney has occupied a prominent and interesting place in both the urologic and general medical literature of the past quarter of a century. During this period there have been great differences of opinion as to the etiology of the cystic kidney. It is generally believed that the cysts are retention cysts and depend upon obstruction at some point along the course of the uriniferous tubule.

The original theory of Virchow that kidney cysts were the outcome of an embryonal or fetal nephritis which caused a fibrosing papillitis, has been abandoned in favor of a theory based purely on developmental defects. The exact site and nature of the developmental fault, however, is still a matter of dispute.

Most workers agree that kidney cysts arise from a failure of proper fusion of the secretory and excretory systems (collecting tubules) during the embryonic formation of the kidney. This is a lack of union between the derivatives of the mesodermal nephrogenic cord and the ureteric buds. Oertel[1] states that incomplete convoluted tubules and loops, actual misdirection in the differentiation of the nephrogenic cell masses, abnormal mesodermal derivatives (muscular and mucoid tissue), abortive abbreviated ureteric buds, adenomatous growths, etc.—all have been found in polycystic kidneys. He further also states

"The question whether there exist fundamental genetic differences in the formation of solitary cysts and the genuine polycystic kidney has been denied by the majority of investigators, who recognize only quantitative differences in these respects. On the other hand, some still emphasize the possibility of certain distinctions in the origin of these two types." Kampmeier[2] claims that this condition is caused by cystic atrophy of the first generation of excretory tubules, that these, instead of being lost, persist and thus prevent the formation of new functional collecting tubules.

However, despite these and many other controversial opinions, pathologists and urologists are today agreed that the polycystic kidney is congenital, developmental in origin and always bilateral.

The purpose of this paper is to add evidence for the theory of the congenital etiology of the polycystic kidney, by presenting the association of this condition with other congenital defects. Of greatest importance is the simultaneous occurrence of spontaneous subarachnoid hemorrhage caused by rupture of congenital "berry" aneurysms of the vessels of the base of the brain.

One of us (H. S. M.), as Chief Medical Examiner of Essex County (Newark) New Jersey, has observed fifty-four cases of spontaneous subarachnoid hemorrhage in a

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series of more than 10,000 routine medico-
legal autopsies performed during the past
twelve years. In thirty-eight of these fifty-

right auricle; and finally a case showing
abnormal position of both adrenals.

This illustrates the well recognized fact

FIG. 1. Case 1. Brain showing spontaneous subarachnoid hemorrhage due to
ruptured congenital aneurysm on right middle cerebral artery. Two un-
ruptured aneurysms may be noted on left middle cerebral artery.

four cases a ruptured, congenital, berry
aneurysm of the circle of Willis, at or near
the bifurcation of its larger branches was
found.

In seven of these instances in which a
congenital aneurysm of the cerebral vessels
was demonstrated, there were other asso-
ciated congenital defects. Three showed
large, bilateral, polycystic kidneys (two of
these cases also had aberrant bile duct cysts
of the liver) whereas four further cases
revealed minor congenital defects—hypo-
plasia of left kidney; stenosis of abdominal
aorta with hypoplasia of left kidney; and
the presence of a Chiari's network in the

that congenital lesions, often of widely
varying character, may frequently be found
to occur simultaneously. Many instances in
the literature illustrate the occurrence of
two, and often multiple, defects in the
same individual.

However, although we have found no
specific reports in the literature per se of
the simultaneous occurrence of polycystic
kidneys and congenital cerebral aneurysms,
a careful study of the literature reveals two
such instances reported along with other
congenital defects. The first such case was
reported by Dunger[3] in 1904. This worker
reports a father, son nad nephew who had

polycystic kidneys; the son died of an aneurysm of the middle cerebral artery. In 1905 Sieber[4] reported 212 cases of poly-

lateral polycystic disease of the kidneys. Autopsy revealed two small unruptured berry aneurysms, one at the junction of the

Fig. 2. Case 1. Congenital bilateral polycystic disease of kidneys. The left kidney weighed 480 Gm., the right kidney 490 Gm.

cystic kidneys. Ten died of cerebral hemorrhage, yet no berry aneurysms were observed; the deaths were regarded as ordinary apoplexies resulting from the hypertension so frequently associated with late polycystic disease of the kidneys.

In 1909, Coombs[5] reported five deaths from cerebral hemorrhage in forty-two cases of polycystic disease of the kidneys. From autopsy reports, however, none of these could be identified with certainty as due to ruptured cerebral aneurysms of congenital origin; six appeared to have been caused by arteriosclerotic changes.

Fearnsides[6] in 1916 reported thirty-one cases of congenital cerebral aneurysms. In but seven of these were complete autopsies performed. In one case, the patient died of renal insufficiency due to congenital, bi-

left anterior cerebral and anterior communicating arteries, the other on the right middle cerebral artery. These were but incidental autopsy findings.

Katz and Müehe in 1924[7] reported a case of a woman who suffered from severe headaches since childhood and who died suddenly at the age of 45. At autopsy a ruptured aneurysm of the anterior communicating artery, and a second unruptured aneurysm at the junction of the internal carotid and right middle cerebral arteries were found, in association with congenital bilateral polycystic kidneys.

It may be said in summary, therefore, that of ninety cases of congenital cerebral aneurysms reported (in thirty papers) in the literature in which adequate autopsy protocols are available, there were only two

cases found of bilateral congenital poly-cystic disease of the kidneys associated with spontaneous subarachnoid hemorrhage.

of this disease is often manifested by renal insufficiency, uremia, coma and death. Thus, such individuals often live to the
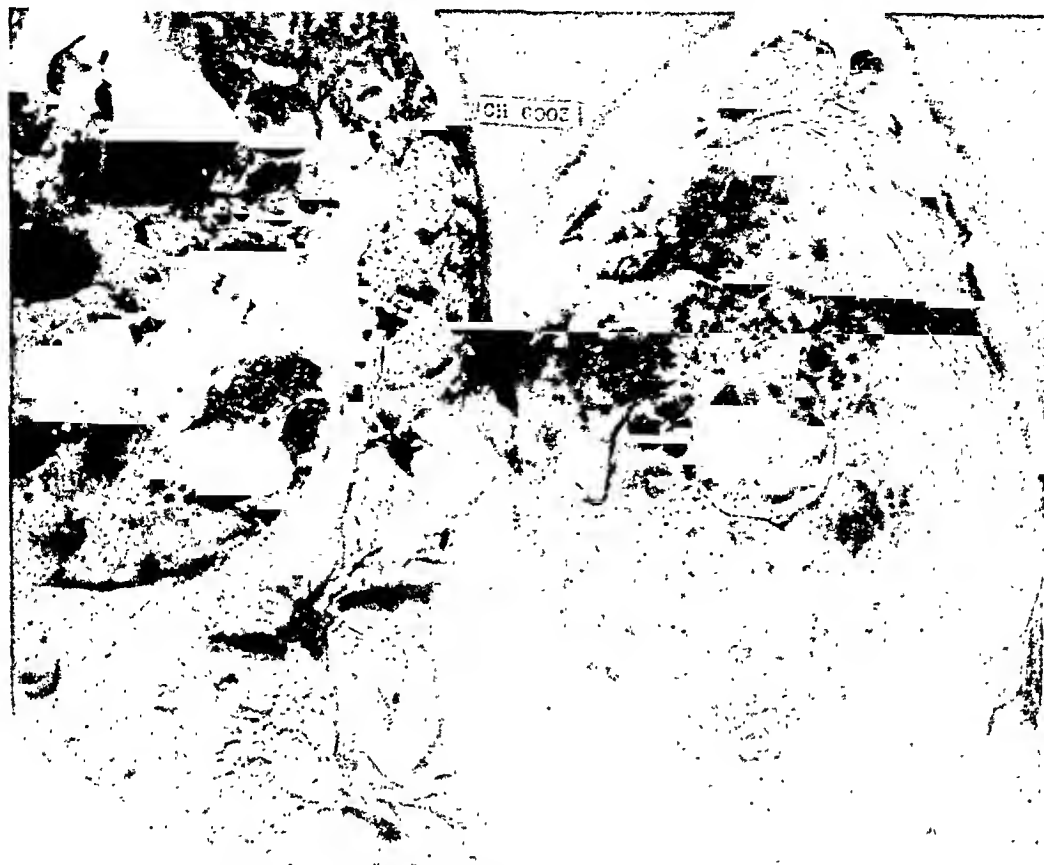
FIG. 3. Case 1. Liver, showing extensive congenital aberrant bile duct cysts.

There are a large variety of other congenital defects which have been reported in association with congenital polycystic disease of the kidneys. Although most of these are of minor importance, gross defects, especially in the stillborn, showing extensive cystic disease of the kidneys and liver, are encountered. These defects occasionally interfere with the mechanism of labor.

Clinicians recognize that bilateral poly-cystic disease of the kidneys may exist throughout most of early adult life as an unsuspected condition. In most instances these individuals gradually develop renal insufficiency, which sooner or later leads to renal hypertension and secondary atheromatous changes in the cerebral and coronary arteries. Except for occasional renal hemorrhage or symptoms produced by pressure, the first evidence of the presence

fourth and fifth decades before symptoms of the disease present themselves. In some cases, however, because of the hypertension and associated blood vessel changes, death may result from cerebral hemorrhage or from coronary disease and its sequelae, rather than from uremia.

Many such cerebral deaths would be diagnosed clinically as ordinary apoplexy. Unless confirmed by autopsy, the accuracy of this diagnosis can never be proved, since some may be due to rupture of congenital aneurysms. Thus, when a cerebral hemorrhage occurs in an individual known to have congenital polycystic kidneys the possibility of subarachnoid hemorrhage due to associated defects in the cerebral arteries of congenital origin must be seriously considered.

THE ASSOCIATION OF POLYCYSTIC DISEASE OF THE KIDNEYS WITH CONGENITAL ANEURYSMS OF THE CEREBRAL ARTERIES

A review of the literature has revealed but two instances of death from subarachnoid hemorrhage caused by congenital cerebral aneurysms in which the autopsy also disclosed bilateral polycystic disease of the kidneys (Cases of Dunger, Katz and Müehe, quoted above).

Of the present series of fifty-four cases of spontaneous subarachnoid hemorrhage, in thirty-eight the bleeding was definitely caused by rupture of congenital berry aneurysms of the circle of Willis or its larger branches. Of these thirty-eight cases, congenital, bilateral polycystic disease of the kidneys was found at autopsy in three instances. Since it is not unusual to observe two or more congenital defects in the same individual, the association of polycystic kidneys and berry aneurysms in the same individual is evidence for the congenital origin of both conditions.

REPORT OF CASES

CASE I. Ruptured congenital berry aneurysm of right middle cerebral artery with spontaneous subarachnoid hemorrhage. Bilateral, congenital polycystic disease of kidneys. Extensive aberrant bile duct cysts of liver. Congenital cyst of spleen. Unruptured berry aneurysm of left middle cerebral artery. No arteriosclerosis or syphilis.

The patient, a white male, 42 years of age, complained of frequent headaches and vertigo. He was suddenly seized with severe headache followed by unconsciousness and convulsions. On admission to the hospital he was in deep coma. The spinal fluid, which at this time contained blood, later became xanthochromic. He remained in deep coma until four days later when death occurred. Clinical diagnosis, spontaneous subarachnoid hemorrhage.

Necropsy. Brain. There was extensive subarachnoid hemorrhage over the inferior and lateral surfaces of the right frontal lobe with secondary rupture into the subdural space and brain parenchyma and an intracerebral clot 5 cm. in diameter. The right lateral ventricle was compressed and convolutions over the superior surface of the brain were flattened. A ruptured, lobulated, berry aneurysm of the right middle cerebral artery was found 2.5 cm. from the origin of this vessel. The aneurysm was 1 cm. in diameter, within the Sylvian fissure, and had ruptured on its superior surface. Two unruptured berry aneurysms, each 4 mm. in diameter, were observed on the left middle cerebral artery.

Kidneys. The left measured 14 × 9 × 5 cm. and weighed 480 Gm. Most of the kidney parenchyma had been replaced by numerous cysts, ranging in size from those just visible to larger ones 1 cm. in diameter. Most of the cysts contained clear serous fluid, others opalescent, cloudy fluid. The right kidney measured 15 × 7 × 6 cm., weighed 490 Gm., and showed the same general appearance and detail as the left kidney.

The liver was markedly enlarged and weighed 3,100 Gm. Both lobes contained innumerable cysts, varying in size from 1 mm. to 4 cm. These cysts contained watery or light yellowish fluid and were lined by smooth, glistening membrane.

The spleen was normal in size and contained a solitary cyst 1.5 cm. in diameter. No hypertrophy of the left ventricle was present and there was no evidence of syphilis or arteriosclerosis except for an occasional yellow streak of atheroma in the aorta.

CASE II. Ruptured congenital berry aneurysm of anterior communicating artery with spontaneous subarachnoid hemorrhage. Bilateral, congenital, polycystic disease of kidneys. Aberrant bile duct cyst of liver. Surgical decompression. Obesity. No arteriosclerosis or syphilis.

A female, white, 56 years of age, was found on the floor of her bathroom where she had apparently fallen, receiving a laceration of the scalp. She was admitted to the hospital in coma, with stiff neck, fever and high blood pressure. The spinal fluid was bloody. A diagnosis of possible traumatic cerebral hemorrhage was made and left temporal decompression performed. The woman lived three days.

Necropsy. Brain. Extensive subarachnoid hemorrhage was present over the inferior surface of both frontal lobes, extending over the base of the brain and lateral surfaces. A ruptured berry aneurysm, 8 mm. in diameter, on the anterior communicating artery near the

left anterior cerebral was accompanied by secondary intracerebral hemorrhage in the left frontal lobe, breaking into the anterior horn of the left lateral ventricle, with extensive interventricular hemorrhage.

Kidneys. The left kidney measured 17 × 10 × 8 cm. and weighed 600 Gm. It was the seat of innumerable small and large cysts, containing clear serous fluid and yellowish and brownish fluid forming a display of color in the cut section of the kidney. Very little kidney parenchyma was recognizable. The right kidney measured 15 × 9 × 6 cm., weighed 510 Gm., and had the same general appearance as the left.

The liver showed one aberrant bile duct cyst 3 cm. in diameter.

The rest of the autopsy was essentially negative except for obesity and evidence of recent surgical decompression. There was no hypertrophy of the left ventricle, no evidence of syphilis or arteriosclerosis.

CASE III. Ruptured congenital berry aneurysm of right middle cerebral artery with spontaneous subarachnoid hemorrhage and secondary hemorrhage in lateral ventricle and subdural space. Congenital polycystic disease of kidneys. No arteriosclerosis or syphilis.

Male, white, 27 years of age had sudden onset of severe headache followed by restlessness, tenderness and rigidity in neck, and unconsciousness. He was admitted to the hospital where he remained in deep coma and died two and one-half days later.

Necropsy. Brain. There was extensive subarachnoid hemorrhage over the inferior surface of the right frontal and temperosphenoidal lobes, extending over the base and lateral surfaces of the brain. A ruptured berry aneurysm 3 mm. in diameter was found on the right middle cerebral artery near the junction of the internal carotid. Secondary hemorrhage into the cerebrum had occurred, breaking into the right lateral ventricle and into the right subdural space.

Kidneys. The left kidney measured 19 × 9 × 7 cm. and weighed 650 Gm. The whole kidney was the seat of extensive small and large cysts, and very little recognizable kidney parenchyma remained. The right kidney measured 21 × 10 × 8 cm. and weighed 800 Gm., and had the same appearance as the left.

No hypertrophy of the left ventricle and no evidence of syphilis or arteriosclerosis were

present except for an occasional patch of soft atheroma in the aorta and coronary arteries.

OTHER CONGENITAL DEFECTS ASSOCIATED WITH CONGENITAL ANEURYSMS OF THE CEREBRAL ARTERIES

Congenital Hypoplasia of Kidney. In this series of fifty-four cases of spontaneous subarachnoid hemorrhage in which a congenital aneurysm was the source of the bleeding in thirty-eight instances, a congenital hypoplasia of the kidney was observed twice.

CASE I. Ruptured congenital berry aneurysm of right middle cerebral artery with spontaneous subarachnoid hemorrhage and secondary hemorrhage into brain parenchyma and subdural space. Congenital hypoplasia of left kidney. Congenital stenosis of abdominal aorta. Compensatory hypertrophy of right kidney.

A white male, 20 years of age, fell while at work in a chemical dye plant. Convulsions and unconsciousness resulted and he died five minutes after admission to the hospital.

Necropsy. Extensive spontaneous subarachnoid hemorrhage was seen over the base of the brain with secondary hemorrhage in the right temperosphenoidal lobe and the subdural space. A ruptured berry aneurysm, 1 cm. in diameter, was present on the right middle cerebral artery, and an unruptured aneurysm, 0.5 cm. in diameter, on the left vertebral artery.

Congenital hypoplasia of the left kidney, which was a miniature kidney with fetal lobulations well retained, patent ureter and congenital stenosis of the abdominal aorta, admitting only the tip of finger, opposite the left renal artery were other congenital anomalies. Compensatory hypertrophy of the right kidney had occurred.

CASE II. Ruptured congenital berry aneurysm of left vertebral artery with spontaneous subarachnoid hemorrhage. Congenital hypoplasia of left kidney with compensatory hypertrophy of right kidney.

A male, white, 40 years of age, was found dead in his automobile.

Necropsy. Extensive spontaneous subarachnoid hemorrhage was found over the base of the brain, most marked about the pons and medulla. There was a ruptured berry aneurysm

of the left vertebral artery 4 mm. in diameter, associated with congenital hypoplasia of the left kidney, miniature kidney, with small renal artery, ureter patent. There was compensatory hypertrophy of the right kidney. Chronic pulmonary tuberculosis was a further finding.

Other Congenital Defects. From reports in the literature, the most frequent congenital lesion found in association with congenital cerebral aneurysms has been coarctation of the aorta. Maude Abbott in 1928,[8] in a series of 200 collected cases of coarctation of the aorta, reported eighteen cases in which death was due to rupture of a congenital cerebral aneurysm. Baker and Sheldon in 1936[9] reported similar cases from the literature.

As noted above, in one case in the present series, the adrenal glands were not in their normal position. The main portion of both glands was situated beneath the capsule of the kidneys. We have observed this anomaly with sufficient frequency during routine autopsies to add support to the original theory of Grawitz, who in 1883, claimed that the so-called hypernephromata, especially those occurring in the upper pole of the kidney, might well be derived from ectopic rests or remnants of adrenal cortex. For this reason we do not favor entire abandonment of the Grawitzian theory for the more dogmatic one which holds that all hypernephromas are renal carcinomas. In spite of perennial argument on this subject in many publications, renal tumors often defy diagnosis and strict pathologic classification.

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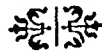
SPONTANEOUS SUBARACHNOID HEMORRHAGE AND CONGENITAL "BERRY" ANEURYSMS OF THE CIRCLE OF WILLIS*

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OF 10,000 routine autopsies performed by the Office of the Chief Medical Examiner of Essex County, New Jersey from 1925 to 1938, 7,500 involved homicide, suicide, highway accident, or other form of violent death. The balance, 2,500 investigations, were instances of sudden or unexplained death, in which autopsy revealed that death was due to natural causes. In this latter group, there were fifty-four cases of spontaneous subarachnoid hemorrhage. Thus in every 100 sudden or unexplained deaths, we should expect to encounter two cases of spontaneous subarachnoid hemorrhage.

A study of these fifty-four cases of spontaneous subarachnoid hemorrhage revealed the association of congenital aneurysms of the circle of Willis and polycystic disease of the kidney, as reported in the preceding paper. The more detailed study of these cases is here made the subject of a separate publication since spontaneous subarachnoid hemorrhage is of interest to diagnosticians, surgeons, and neurologists, whereas the previous study is of greatest value to urologists.

SPONTANEOUS SUBARACHNOID HEMORRHAGE

DEFINITION

In spontaneous subarachnoid hemorrhage (in which there is no disease of the brain, meninges or skull) the bleeding occurs between the arachnoid and the pia mater.

This takes place almost always at the base of the brain, and though the blood spreads widely, it is still confined to the subarachnoid space. If the hemorrhage be of large amount, the blood may follow this potential space and spread over the lateral and superior surfaces of the brain, and even extend down the brain stem, producing rapid death by compression of the medullary centers. Finally, the extravasated blood may rupture into the subdural space or into the brain parenchyma, and may by this route burst into the lateral ventricles.

The application of the term "spontaneous" to this form of subarachnoid hemorrhage is not accurate, since most cases are due to the rupture of preëxisting aneurysms of the cerebral arteries. However, because of common usage, any attempt to abandon or alter the terminology would only lead to confusion.

Spontaneous subarachnoid hemorrhage must be differentiated from forms of traumatic subarachnoid and intracerebral hemorrhage. The former results from direct or contrecoup laceration of the cerebral cortex (usually associated with fracture of skull), whereas the latter are hemorrhages which originate within the brain substance as a result of ordinary apoplexy, telangiectatic brain tumors, or deep traumatic lesions of the parenchyma (any of these may secondarily break into the subarachnoid space—secondary subarachnoid hemorrhage).

INCIDENCE

Spontaneous subarachnoid hemorrhage has long been regarded as a rare condition, and one which is chiefly of pathologic interest. However, since pathologists have called attention to this condition, and since lumbar puncture has become a common diagnostic procedure, the clinical diagnosis of this condition is a more frequent occurrence.

Fatal Cases. In spontaneous subarachnoid hemorrhage the onset is sudden and soon followed by death. Therefore, the medical examiner and coroner's physician see more instances of this condition than are to be observed in routine hospital or private practice. As noted above, in our experience, 2 per cent of sudden deaths are caused by rupture of aneurysms of the circle of Willis and its larger branches. The age, sex and race of fifty-four fatal cases are indicated in Table I.

TABLE I

AGE, SEX AND RACE IN FIFTY-FOUR DEATHS FROM SPONTANEOUS SUBARACHNOID HEMORRHAGE

Age	Cases
10 to 20 years	5
20 to 30 years	13
30 to 40 years	7
40 to 50 years	12
50 to 60 years	13
60 to 70 years	4
Sex	
Males	27
Females	27
Race	
White	45
Colored	9

The youngest fatality in this series was at the age of 14, the oldest 67 years, whereas the greatest incidence is in the third, fifth and sixth decades. In the second decade, congenital hypoplasia of the cerebral arteries, without aneurysm, but often associated with status lymphaticus, account for most of the deaths.

Spontaneous Subarachnoid Hemorrhage Followed by Recovery. Ayer,[1] along with many other clinicians, believes that 50 per cent of patients with spontaneous subarachnoid hemorrhage may recover. And, Bramwell,[2] states, that although the onset is abrupt and the patient unconscious, those individuals who recover, do so quickly—there is only a short period of unconsciousness. "He may be drowsy or stuporous; sometimes he is confused, irritable, and resistive; and he usually complains of 'terrible' headache. . . . The extravasation in such cases has not been excessive and the fact that the patient is now conscious or less drowsy suggests that the hemorrhage has been arrested." The symptoms in such cases have, for the most part been attributed to a small extravasation from a cerebral aneurysm.

However, in our opinion these cases are not due to leaking or ruptured congenital aneurysms. We believe some other less serious lesion must account for these smaller and more localized hemorrhages, from which patients may recover. This opinion is based upon the fact that the pathologic residua of healed ruptured aneurysms are rarely seen in large autopsy services (brown stains in leptomeninges due to hemosiderin deposits in the region of the aneurysm). There is little anatomic proof that "berry" aneurysms rupture and heal, and less proof that these aneurysms may become thrombosed and absorbed. It is interesting to note that Boyd[3] states, "These aneurysmal cases are usually fatal. There is another group of cases which usually recover and are probably due to some rather mild infection, some meningo-encephalitis, which especially attacks the vessels. They occur in groups of little epidemics, a fact which serves to strengthen the idea that they are infectious, although of this there is no direct proof."

The recent recognition of obscure cases of (microscopic) necrotizing arteritis* may possibly account for some of these cases.

PATHOLOGY

The pathologic lesions in fifty-four fatal cases of spontaneous subarachnoid hemorrhage are detailed in Table II.

* An infectious, often widespread disease of the smaller arteries which some believe to be a form of periarteritis nodosa caused by rheumatic virus, allergy or what-not.

Ruptured congenital "berry" aneurysms 38
Undetermined source of bleeding. 5
   (Small aneurysms probably not discovered at
   autopsy)
Ruptured hypoplastic cerebral arteries. 9
   (Associated usually with status lymphaticus)
Ruptured aneurysm due to arteriosclerosis. 1
Ruptured arteriosclerotic vessel. 1
                                              —
                                             54

Extensive spontaneous subarachnoid hemorrhage is usually due to rupture of a congenital aneurysm of one of the larger cerebral arteries in or near the circle of Willis. When the aneurysm is not found at autopsy, either it may have been missed due to lack of proper autopsy technique, or else the defect may be overlooked because the aneurysm has entirely "blown out" and is lost in the torn tissues and surrounding hemorrhage.*

Spontaneous subarachnoid hemorrhage in association with congenital hypoplasia of the cerebral arteries and often with status lymphaticus (a condition which the author still believes exists), often show parenchymal hemorrhage, most frequently in the cerebellum and occipital lobes. It is questionable whether all of these cases should be included in this series, since the subarachnoid hemorrhage is occasionally secondary. One of these patients also showed congenital cystic disease of the lungs, and still another, a moderate degree of subaortic stenosis (another congenital lesion).

Since almost all cases of fatal spontaneous subarachnoid hemorrhage are caused by a rupture of an aneurysm of the cerebral arteries and in the majority of cases such an aneurysm when it occurs in or near the

* It has been our practice when diffuse subarachnoid hemorrhage is found at autopsy over the base of the brain to turn the base upward and gently spread it apart by placing a block of wood beneath it. Blunt dissection and scraping of the entire circle of Willis and its larger branches, using a scalpel and a fine stream of water will usually reveal the aneurysm. This is important, since innocent persons have been convicted of manslaughter in assault cases due to the bungling methods of some pathologists.

circle of Willis is due to a congenital defect in the arterial wall, a discussion of the pathogenesis of cerebral aneurysm is in order.

Congenital or "Berry" Aneurysms. In 1887, Eppinger[4] first suggested that the small saccular aneurysms of the circle of Willis or its larger branches (particularly at the bifurcations) were congenital defects of the arterial wall. Eppinger called these "berry" aneurysms because of their shape and color. Such aneurysms are usually small, from 3 mm. to 1 cm. in diameter, and have the appearance of a small berry. They are most commonly found on the main vessels of the circle of Willis or on its larger branches, usually, but not always at or near the bifurcation of a large vessel. These defects may be sometimes multiple, and occasionally are encountered as incidental autopsy findings during routine autopsies.

In 1930, Forbus[5] demonstrated that the arterial walls in this condition characteristically lack a muscular coat at the point of sacculation of these aneurysms. He pointed out that such a defect might arise from failure of proper embryonic fusion of the separately developed muscle coats of the main vessels and its branches. From microscopic studies Forbus further concluded that these aneurysms developed from a combination of two factors: a focus of weakness in the vessel wall as a result of the defect in the muscularis, and subsequent degeneration of the intimal elastica because of continued stretching due to the blood pressure.

Recently Helpern[6] has again emphasized the importance of the recognition of these congenital berry aneurysms as a cause of sudden death and supports the views of Forbus as to their pathogenesis. Helpern, on microscopic examination of these aneurysms, found that the aneurysmal wall was almost devoid of both the internal elastica and the muscularis, and was composed of a slightly thickened continuation of the intima and adventitia. Furthermore, he calls attention to the fact that occasionally when these lesions are near the surface of

the brain, rupture may produce a large subdural hemorrhage with little or no subarachnoid bleeding, and in such cases the spinal fluid may contain no blood whatsoever.

Other workers claim, however, that these microscopic findings are often difficult or impossible to demonstrate and that such medial defects may often be very irregularly distributed. Karmally and Manohar,[7] though believing that most of these aneurysms are congenital, still claim that the defects of the media do not fully explain their formation. These observers hold that the embryologic theory of the cause of these defects will not always explain the formation of berry aneurysms, since the imperfections in the media may occur some distance from the site of branching of the vessels, which is the common location of berry aneurysms. They conclude that further histologic studies are necessary before congenital aneurysms can be satisfactorily explained.

Most pathologists, however, believe that these lesions are of congenital origin, and that rupture of such berry aneurysms is the most common cause of fatal spontaneous subarachnoid hemorrhage in either the young or old who are free of syphilis or arteriosclerosis.

Of the fifty-four cases dying of spontaneous subarachnoid hemorrhage reported herein, these congenital berry aneurysms were found in thirty-eight; in eleven cases the hemorrhage was due to other lesions, and in the remaining five, no aneurysm or other lesions could be discovered or identified. (See Table II.)

Aneurysms Due to Arteriosclerosis. Extensive atheroma of the arteries at the base of the brain may cause aneurysmal dilatation of the vessel or an actual aneurysm. These lesions are often larger than a berry aneurysm and occasionally may cause symptoms of intracranial pressure before rupture occurs. These may occasionally be diagnosed from the history, or from the presence of paralysis of the third and sixth cranial nerves.

In this series of fifty-four cases of spontaneous subarachnoid hemorrhage there was but one aneurysm due to arteriosclerosis. This occurred in a white female, age 54, who died suddenly. Autopsy revealed hypertensive cardiovascular disease and a large, irregular aneurysm of the basilar artery, 2 cm. in diameter, surrounded by extensive subarachnoid hemorrhage.

Aneurysms Due to Syphilis. Syphilis is but rarely the cause of aneurysms at the base of the brain. Fearnsides in 1916[8] found that in his cases that syphilis could seldom be identified as a possible etiologic factor in the production of these aneurysms. He felt that when these occurred, the lesions were chiefly of the basilar or vertebral arteries, and grew to such size as to give rise to pressure symptoms before rupture.

Martland in 1932[9] has stated that "Syphilis is frequently seen in the cerebral arteries as a periarteritis, and because of the small caliber of the vessels, an added obliterating endarteritis is liable to produce thrombosis rather than aneurysm (Endarteritis obliterans luetica of Heubner)."

In this series of cases of spontaneous subarachnoid hemorrhage, there were none which could be attributed to syphilis.

Mycotic Aneurysms. In rare instances an infected embolus (usually as a complication of subacute bacterial endocarditis) may cause subarachnoid or intracerebral hemorrhage either by the production of a mycotic aneurysm or as the result of so-called toxic effects on the walls of the capillaries, without the actual formation of an aneurysm. When the hemorrhage is extensive, the presence of such aneurysms is very difficult to ascertain.

Of the fifty-four cases suffering from spontaneous subarachnoid hemorrhage here discussed, none were due to mycotic aneurysms, although sudden death from intracerebral hemorrhage in subacute bacterial endocarditis has been observed a number of times during the past twelve years.

Other Causes. Spontaneous subarachnoid hemorrhage may occasionally occur

in leucemia, purpura and sometimes in septicemia, without any demonstrable gross lesion in the brain or meninges. These are usually attributed to the hemorrhagic diathesis, but occasionally in leucemia microscopic sections may show thrombosis of capillaries by leucemia cells. The possibility of infectious necrotizing arteritis causing subarachnoid hemorrhage has been noted above.

Relation of Trauma. In our series, twenty-one of the fifty-four patients with spontaneous subarachnoid hemorrhage gave some history of falls or minor injuries —in street, bathroom, after fist fight, bumping head in train, while fighting fire, etc. However, careful autopsies failed to reveal any serious injuries. In most cases the onset is sudden, and with the rupture of the aneurysm the patient often falls and sustains an injury. Since almost every known disease has been attributed to trauma in the compensation courts, and substantial awards have often been given, it is easily seen how involved this problem may become.

In most arguments before compensation courts regarding the relation of trauma to disease, two important questions always arise. Was the injury the direct cause of the disease, and if not, did it aggravate the preëxisting condition. There are some workers who still believe that berry aneurysms may occasionally result from or follow a head injury. However, we do not feel that this view is tenable in the light of careful pathologic studies of this problem. We have never encountered an aneurysm of the circle of Willis which could be proved to originate as the direct result of an injury.

Berry aneurysms usually rupture spontaneously. There is no doubt, however, that in some cases actual rupture may be precipitated by trauma, or physical exertion, and especially trivial exertions which produce a rise in blood pressure, such as straining at stool, lacing shoes, sexual intercourse, sneezing, etc. Trauma can rarely be considered a causal agent and while the above conditions may have some

medicolegal importance the same catastrophe occurs during sleep. The rupture is usually so abrupt, often with no apparent determining factor, that the attack is of the nature of an accident.

In summary it may be stated that aneurysms tend to rupture because of: superimposed changes in the vessel wall; increased blood pressure; in a few cases because of physical effort, strain, emotions, or rarely, because of trauma.

SYMPTOMS AND PHYSICAL SIGNS

As recently as 1934, Garvey[10] reviewed the clinical symptoms, etiology and pathologic findings in aneurysms of the circle of Willis and stated that "the diagnosis of intracranial aneurysm cannot be made with any degree of certainty until rupture occurs." The clinical syndrome produced by rupture, however, is usually characteristic.

The symptoms of rupture are often dramatic. Howell[11] states, "The patient calls out in pain, and may then fall unconscious; indeed, the diagnosis is often made on the history of a cry of 'Oh! my head!' followed by unconsciousness." Bramwell[2] states that the patient may be in robust health or may have complained of premonitory headache for some time, when he is suddenly seized with an intense "throbbing" or "bursting" headache, often accompanied by vertigo and vomiting. This is followed almost immediately by coma. The breathing becomes stertorous, the pupils dilated, the pulse slow and perhaps irregular, and the temperature usually rises. Neck rigidity and Kernig's sign are often present; the patellar reflexes are diminished or absent, the plantar reflexes are frequently extensor in character, and ophthalmoscopic examination may reveal hemorrhages in the retina. If the patient becomes deeply comatose, the prognosis is extremely grave.

The characteristic syndrome of rupture of an aneurysm of the circle of Willis then consists of sudden headache, vomiting, followed quickly by an apoplectic seizure with rapid loss of consciousness, at times

convulsions, and deep coma. If death does not ensue, the patient may regain consciousness. This is apt to be followed by severe headache, photophobia, stiffness of the neck and other signs of meningeal irritation.

Examination of the spinal fluid during the first twenty-four to forty-eight hours after the rupture shows a uniformly bloody fluid under increased pressure. Later the spinal fluid may become xanthochromic. If there is doubt as to whether the blood in the spinal fluid is the result of the lumbar puncture, this question can be settled by comparing the depth of color of each of two or three samples collected in separate test-tubes. After standing, the supernatant spinal fluid will be yellow-tinged in cases of subarachnoid hemorrhage, but colorless after "traumatic" puncture.

Large hemorrhages are sometimes found in the retina, especially around the optic disk. The mechanism of the production of these hemorrhages is not clear, and they have been attributed to extravasation of blood along the optic nerve sheath or to obstruction of the central retinal vein within the optic sheath, with resulting venous stasis. Papilledema, as a rule, is absent.

In addition, certain localizing signs may be present, either before or after rupture, depending upon the site and size of the aneurysms. Aneurysms of the internal carotid artery within the cavernous sinus or just at the entrance into the cranial cavity are more apt to produce oculo-motor paralysis with ptosis and iridoplegia. The paralysis occurs on the side of the aneurysm. These aneurysms may give rise to exophthalmos, amblyopia, and hemianopsia. Rupture into the cavernous sinus causes pulsating exophthalmos.

Aneurysms of the internal carotid artery at the point of origin of posterior communicating, ophthalmic, anterior and middle cerebral arteries, are more apt to produce ocular syndromes of the chiasmal or prechiasmal type with characteristic field defects rather than cranial nerve palsies.

Friedman[12] states:

"That aneurysms of the anterior cerebral artery may compress the optic and olfactory nerves. In the middle cerebral artery, it may involve the olfactory nerve in addition to the oculomotor. The pressure is, for the most part, exerted on the brain substance and gives rise to aphasia, monoplegia, or hemiplegia. Aneurysm of the posterior communicating artery may produce hemianopsia by implication of the optic tract.

"Aneurysm of the basilar artery exerts pressure chiefly against the pons, medulla, or peduncle. The patient with such a lesion usually experiences pain in the occipital region and difficulty in moving the head. Compression of the pons with symptoms of alternating subacute hemiplegia or bulbar paralysis may be evident. Manifestations of irritation or paralysis are sometimes referable to the individual cranial nerves. In aneurysm of the basilar artery the hemiplegia shifts from one side to the other without ever disappearing completely until finally the condition becomes a diplegia or paraplegia. Vomiting and respiratory embarrassment are particularly apt to occur in these cases.

"Aneurysm of the vertebral artery evokes similar symptoms, and in some individuals the palate and vocal cord on one side and the hypoglossus on the other side may be involved."

Most such localizing signs, however, are observed when larger aneurysms are situated on the internal carotid or at the origin of its larger branches and are of little diagnostic use in the vast majority of intracranial aneurysms which occur on the circle of Willis and which, as a rule, are symptom free until rupture occurs.

DIAGNOSIS

The diagnosis of aneurysm of the circle of Willis cannot usually be made before rupture. However, the diagnosis after rupture can often be made with a considerable degree of certainty. The characteristic clinical syndrome is described above, and

the differential diagnosis of coma, without a history of syphilis or hypertension, should include a consideration of this condition. If the coma is deep, this disease must be distinguished from cerebral hemorrhage (apoplexy). Symptoms pointing to the region of the internal carotid (oculomotor signs or trigeminal phenomena) are highly suggestive. If in addition we find retinal hemorrhages, bloody or xanthochromic spinal fluid, the diagnosis of subarachnoid hemorrhage may be made.

Spontaneous subarachnoid hemorrhage must also be differentiated from subdural hematomas and other forms of traumatic intracranial hemorrhage, from the various types of ophthalmoplegia, from migraine with or without ophthalmoplegia, from tumor of the trigeminal nerve and from infectious meningitis.

Lately it has become possible to diagnose a small number of unruptured intracranial aneurysms. This is made possible by careful neurologic examinations, expert roentgenographic and encephalographic studies, and arteriograms. However, these few instances are chiefly aneurysms situated on the internal carotid artery or at the origin of its main branches. These defects reach a large size and impede the surrounding circulation, press upon cranial nerves and erode adjacent bone. Unfortunately, these represent a very small number of intracranial aneurysms and are reported, for the most part as individual cases, by neurologists (often to demonstrate their skill in the localization of cerebral lesions).

In 1926, Sosman and Vogt[13] described the roentgenographic diagnosis of unruptured aneurysms of the circle of Willis. They state:

"The recognition of these aneurysms on Roentgen examination is by means of (1) calcification in the wall of the aneurysm, or (2) erosion of the bone adjacent to the aneurysmal sac. In the first, one can see thin plaques of calcium, usually semilunar in shape, with their convexity upward, lying beside the sella, or should the aneurysm be large, rising above the level of the sella, but just to one side of it. These are fine curvilinear shadows, sharply outlined, occasionally segmented, and easily recognizable as being in the wall of a cystic or rounded structure. . . . The erosion due to these pulsating sacs. . . . involves or may involve one anterior clinoid, the lateral half of the body of the sphenoid on the same side, and a similar portion of the posterior clinoid. . . . There is no expansion of the pituitary fossa . . . and no apparent depression of the floor of the fossa. The opposite anterior clinoid is not involved . . . and there is no pressure atrophy or forward bending of the posterior clinoid."

Such calcific deposits in the wall of the aneurysm, revealed by roentgenograms as concentric circular shadows, are known as Albl's rings. Further, the injection of thorotrast into the internal carotid artery followed by roentgenography may outline some aneurysms.

PROGNOSIS

It is of interest to note the duration of life in the fifty-four cases of spontaneous subarachnoid hemorrhage herein reported. They are tabulated in Table III.

TABLE III
DURATION OF LIFE IN FIFTY-FOUR CASES
OF SPONTANEOUS SUBARACHNOID HEMORRHAGE

	Cases
Sudden death	21
(Found dead, dying within thirty minutes after collapse, dead on arrival at hospitals, etc.)	
Slower death	33
Lived approximately	
1 hour after attack	6
2 hours after attack	6
3 hours after attack	5
3–12 hours after attack	3
1 day after attack	4
2 days after attack	2
3 days after attack	2
4 days after attack	2
5 days after attack	1
6 days after attack	2

The patients lived six days, this being the longest duration of life in this series.

Most authorities agree that though many patients with spontaneous subarachnoid

hemorrhage die suddenly, the majority may live a sufficient length of time to remove them from the classification of "sudden deaths." In many cases classified as sudden death, such as those found dead in bed or at home, etc., it is often difficult to ascertain just how long the patient has survived after the rupture of the aneurysm. There is strong evidence, however, that many die shortly after the onset, and such individuals fall in the street or at home, are picked up dead, or are dead on arrival at hospitals. They almost never die instantaneously, however, and many survive minutes, hours or longer. In our experience, one-half of the fatal cases of spontaneous subarachnoid hemorrhage died within an hour of the rupture, the rest lived a few hours or days, but rarely longer than one week.

We are extremely doubtful about the presence of intracranial aneurysms in that 50 per cent of cases of spontaneous subarachnoid hemorrhage which are reported to have recovered.

CONCLUSIONS

1. Many of the observations in this series are at variance with descriptions of intracranial aneurysms given in textbooks and in the literature.

2. Practically all cases of fatal subarachnoid hemorrhage are caused by rupture of intracranial aneurysms.

3. We believe that most of those cases of spontaneous subarachnoid hemorrhage which recover (50 per cent according to some clinicians) are probably not due to "leaking" or ruptured intracranial aneurysms, but rather to some unexplained infection or to some as yet unknown cause. There is little anatomic proof that intracranial aneurysms leak, rupture and heal, or bleed at various intervals, and less proof that intracranial aneurysms may become thrombosed and disappear.

4. In our experience, by far the most common type of intracranial aneurysm is the congenital "berry" aneurysm of the circle of Willis and its larger branches.

Such aneurysms are usually saccular, often multiple, and microscopic examination shows little or no evidence of inflammation. Usually the aneurysmal wall is almost devoid of muscularis and internal elastica. These aneurysms are not always situated at the bifurcation of large branches of the circle of Willis.

Contrary to the view of most authorities, there is no predilection for any particular branch of the circle of Willis nor for either side of the brain. A large series shows that these sacculations occur more or less symmetrically over the whole circle of Willis. (See Fig. 1.) They are infrequent on the internal carotid artery.

In addition, the association of this condition with other congenital defects, such as polycystic disease of the kidney and liver, as well as other renal anomalies, further supports the theory of congenital origin.

Intracranial aneurysms due to arteriosclerosis (cerebral atheroma), syphilis, bacterial endocarditis, and other causes are so rare that these types are of little practical importance as a cause of fatal subarachnoid hemorrhage. When such aneurysms do occur, however, they are usually situated on the deep cerebral arteries and when rupture occurs, they cause primary hemorrhage within the brain substance, often accompanied by secondary hemorrhage into the subarachnoid space.

5. Aneurysms of the circle of Willis rarely give rise to symptoms before rupture, and the majority will defy recognition. Those few diagnosed before rupture are larger aneurysms, situated often on the internal carotid arteries or near their main branches, which by pressure on circulation or on nerves, or by erosion of bone, give rise to localizing symptoms and signs. These are chiefly of neurologic interest.

6. When an aneurysm of the circle of Willis ruptures, a characteristic syndrome results which makes the diagnosis of this condition more or less certain.

7. We believe that trauma is never the direct cause of aneurysms of the circle of Willis. However, undue exertion, emotions,

trauma, or anything that may raise the blood pressure, may precipitate rupture and thus assume some medicolegal importance.

9. In this series of fifty-four cases of spontaneous subarachnoid hemorrhage there is no special sex or race distribution.
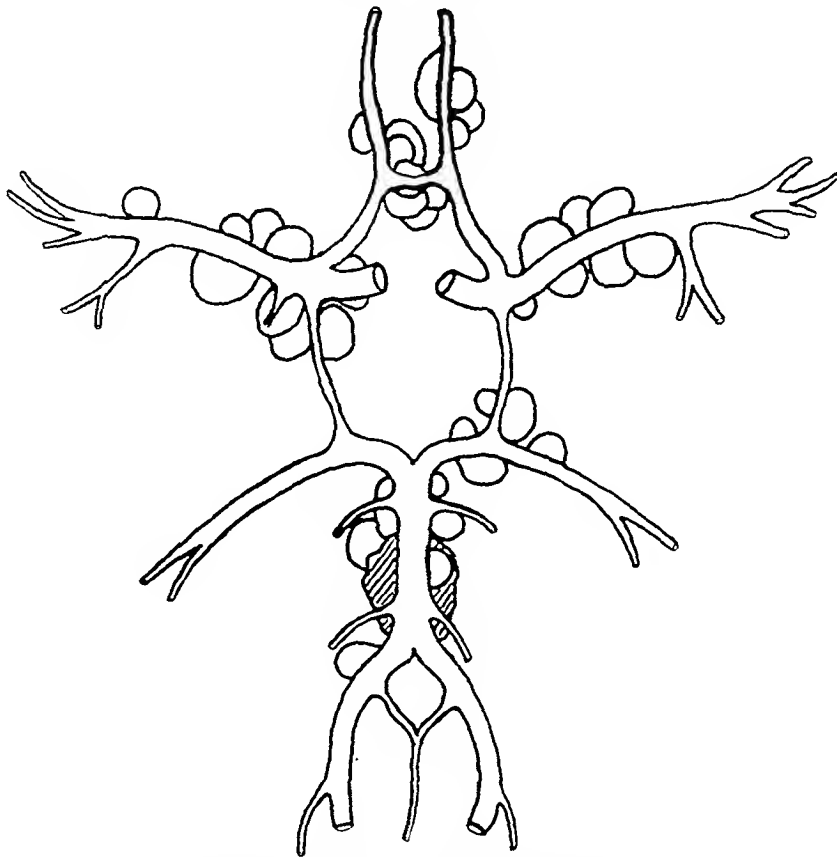
FIG. 1. Circle of Willis with position and relative size of thirty-eight congenital "berry" aneurysms, found at autopsy in fifty-four cases of spontaneous subarachnoid hemorrhage. A larger aneurysm (shaded) on the basilar artery, due to arteriosclerosis, is also shown.

Contrary to most authorities, it may be noted that there is no predilection for any particular branch of the circle of Willis nor for either side of the brain. A large series shows that these congenital berry aneurysms occur more or less symmetrically over the whole circle of Willis and its branches. They are infrequent on the internal carotid arteries.

The same arguments can be advanced for many coronary attacks. However, the rupture is most often spontaneous and bears no relation to any known factor.

8. Spontaneous subarachnoid hemorrhage due to ruptured aneurysms of the circle of Willis is by no means a rare catastrophe and in our experience about 2 per cent of sudden or unexplained deaths encountered by medical examiners are due to this condition.

After rupture, one half of the patients die within an hour, the rest live but a few hours or days, and only a few live a week or longer.

Most deaths occurred in the third, fifth and sixth decades. The younger individuals usually show no atheroma or evidence of syphilis. The older cases often reveal the ordinary amount of arteriosclerosis which is compatible with the age of the individual.

10. There is no effective treatment for this catastrophe. There are no means of prevention, since the aneurysmal fault is usually congenital. The condition is unpredictable, cannot be prevented, and little hope can be offered at this time for any rapid advance in diagnosis or treatment.

11. Since in spontaneous subarachnoid hemorrhage the very character of the

onset is frequently in the nature of an accident, and is often associated with a fall or other injury, it must be differentiated from various cranial injuries and types of intracranial hemorrhage. Traumatic and neurosurgeons should, therefore, be familiar with this condition.

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Ice tong traction [in fractures of the shaft of the femur] is not without its dangers and should be discarded in favor of Kirschner wire traction.

THE ROLE OF PRELIMINARY MEDICATION IN THE PREVENTION OF ANESTHETIC DEATHS

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IN 1935, Henson[4] reported having sent questionnaires to all the hospitals in New York City, numbering 213, requesting the number of the various anesthetics administered during the five year period 1928 to 1932, inclusive. Fifteen replies were received, involving ether, nitrous oxide, ethylene, spinal, local and avertin.

From the Chief Medical Examiner's Office it was found that 219 deaths were apparently caused by anesthesia. This is an average of forty-three deaths per year, a mortality which appears relatively insignificant when viewed from the standpoint of the number of anesthetics administered, but which appears in a different light on realization of the actual number of persons dying from this cause. These deaths were thought to be true anesthetic deaths, to which no pathologic condition of the patient contributed.

In 1937, after a continuance of the study, involving a larger number of anesthetic agents and combinations thereof, Henson[5] concluded that the two investigations had proved that the average number of deaths due to anesthesia per year in the five boroughs of New York was forty-six.

If it is assumed that a cross section of the country is represented by the findings in New York City hospitals, Dr. Henson's statistics would seem to prove that anesthetic deaths have not decreased notwithstanding the development of new agents and improvements in technique. The problem, then, naturally and logically centers around the determination of an agent or agents to be employed, as well as a method or methods of administration, by which these unnecessary deaths may be reduced to a minimum or prevented altogether.

THE MEDICAL AND NURSE ANESTHETIST

While advocating the training and careful regulation of anesthetists, among other considerations, Henson seems to predicate reduction in anesthetic mortality chiefly on the exclusive use of ethylene, with the necessary precautions, as no deaths were reported in this series from ethylene.

In the discussion of Dr. Henson's first paper, Dr. Paul M. Wood of New York City expressed the view that seldom is the agent any more at fault than the method and skill of the anesthetizer. "Given a properly trained and qualified anesthetist, morbidity and mortality will fall, regardless of agent, technique or patient's condition." This point of view was crystallized by the American College of Surgeons in a statement in its 1936 Year book.[9] The statement in part follows:

"The science of anesthesia is rapidly developing. New types of anesthesia, new methods of administration, and complicated apparatus demand serious medical thought. It is unfortunate that a large number of hospitals fail to recognize the necessity and value of a well organized department of anesthesia. This presupposes competent medical supervision, preferably a medical anesthetist. . . . Such a requirement does not preclude the use of the nurse anesthetist who is properly trained and qualified to give anesthesia. It is unfair to expect the nurse to be responsible for the service, but rather she should work under proper medical supervision. As the administration of anesthesia is generally conceded to be the practice of medicine and inasmuch as it involves risk to human life, it is only reasonable to expect medical supervision. This cannot be done properly

by the surgeon, for he is frequently not specially trained in this work, nor should he have to carry the responsibility when under the strain of operating."

Undoubtedly a great advance toward the reduction of anesthetic mortality and morbidity would be made if all medical colleges and hospitals would place in charge of the teaching of anesthesia and the administration of anesthetics competent medical anesthetists who would initiate such methods as would give the safest and most efficient anesthesia. Under these circumstances the patient and the surgeon would be assured of the use, not only of the agent best suited to the case, but of such adjuvant principles of administration as are known to increase the margin of safety.

COMBINATIONS AND SEQUENCES

In his investigations, Henson has developed more clearly than any other writer that statistically nitrous oxide is a very unsafe anesthetic and that ethylene is an unusually safe agent. Luckhardt[7] demonstrated these facts in the laboratory; clinical history has verified and confirmed his findings that ethylene is safer than nitrous oxide. It is a mistake, however, to use either ethylene or nitrous oxide alone; safety lies in using them in sequence and combination, with a trained anesthetist adjusting the requirement for the given case. The majority of anesthetists prefer to have all known anesthetic agents at their command and to use them as indicated by the condition of the patient and the nature of the surgical operation.

THEORETICAL CONSIDERATIONS

In his second paper, Henson[5] reports a total of sixty-one deaths previous to operation (presumably less than ten minutes before), and thirty-two within approximately ten minutes of the commencement of the operation. This total of ninety-three deaths represents nearly 50 per cent of the entire number of deaths reported with the time of occurrence of death and the agent stated. All or nearly all of these deaths

could have been avoided by utilizing technique based on laboratory experiments and clinical observations.

LABORATORY EXPERIMENTS

It has been proved experimentally[*] that when ether is administered intravenously without preliminary medication nearly twice as much anesthetic is required to produce anesthesia as when preliminary medication is used. Again, without preliminary medication a very small amount of ether produces respiratory paralysis, whereas with preliminary medication two and a half times the amount of ether is required to produce this same result. This proves that a laboratory animal is much safer with preliminary medication than without. The above experiment was verified several years later with ether, propylene, acetylene, ethylene, and nitrous oxide administered by inhalation.

This research was under the supervision of the late Charles W. Hooper, assisted by the writer. It represents a year's work, in which approximately 500 animals were employed to determine the value of preliminary medication in inhalation anesthesia. Half of the animals were used as controls and the other half were given preliminary medication; all of them were placed in the same gas chamber. The animals without preliminary medication had a stage of excitement, jumped around and struggled against the anesthetic. The animals with preliminary medication never moved, but sank quickly and quietly under the anesthetic, and lived twice as long as the controls in the same gas chamber. Necropsy revealed that the lungs of the animals that received preliminary medication were relatively normal. The lungs of the animals without preliminary medication on gross examination showed distention, edema and congestion. Microscopic lesions were perivascular edema, diffused

petechiae, and alveolar spaces filled with fluid. The bronchi contained edematous fluid. Other organs appeared normal.

have been evolved from laboratory experiments. Therefore, on the basis of the extensive and careful laboratory experiments

Nitrous oxide 93 per cent, oxygen 7 per cent.
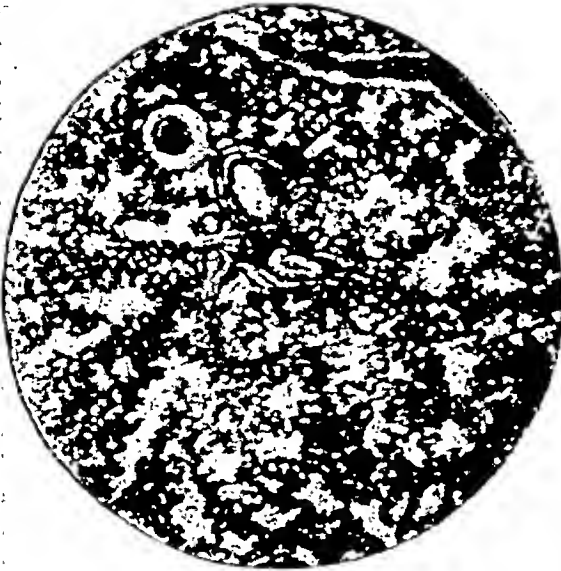
FIG. 1. No preliminary medication. Air spaces filled with edematous fluid; perivascular edema; congestion.
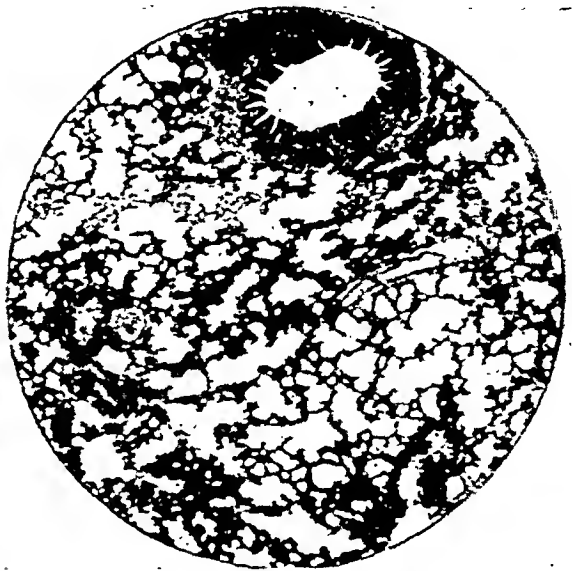
FIG. 2. *Preliminary medication.* Air spaces and bronchi clear; no perivascular edema or congestion.

Ether vapor 34 per cent, oxygen 66 per cent.
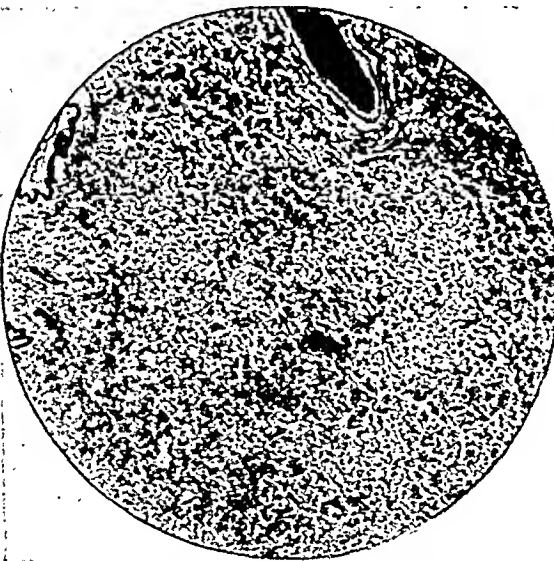
FIG. 3. No preliminary medication. Massive atelectasis and congestion; air spaces obliterated.

FIG. 4. *Preliminary medication.* Lung tissue relatively normal.

The work of Charles W. Hooper, assisted by the author. From Autochrome photomicrographs in Nelson's Looseleaf Surgery, Vol. 1, page 514.

PRELIMINARY MEDICATION

As we know, all advanced surgical work is based on laboratory research. Many of the most scientific methods in anesthesia

with preliminary medication, it is safe to assume that at least 50 per cent of the deaths reported by Dr. Henson as occurring previous to operation and within approximately ten minutes of the commencement

of operation, could have been prevented by the use of preliminary medication.

It has been my experience that preliminary medication is a life-saving measure, some form of which should be employed whenever possible. The ideal preliminary medication has not been found, as such medication should combine within itself the terminal anesthetic. However, the agents or combinations thereof now available which meet certain outstanding requirements (notably elimination of *psychic* reflexes, with the attendant rise in blood pressure) will bring the patient to the state or condition corresponding to that of an animal given preliminary medication in the laboratory, i.e., partial or complete insensibility when brought to the operating table.

Morphine (¼ grain) and atropine (1/150 grain) form an unsatisfactory preliminary medication as they do not abolish the psychic reflexes. A tremendous rise in blood pressure is always present preceding the initiation of the anesthetic.[1]

Several new preliminary medicaments have been introduced within the last few years that have proved satisfactory and entirely safe. Notable among these is nembutal (pentobarbital sodium) and evipal soluble.[3] Whatever the agent, the timing of its administration so that its maximum effect is produced as the patient is brought to the operating table is most important.

Nembutal has been used in over 2,000 consecutive cases of adenoid and tonsil operations in the City Hospital of New York.[2] The children are sound asleep when brought to the operating table. The fright and struggle which usually accompany anesthesia in children who have not received preliminary medication are eliminated. The sleep is converted into surgical anesthesia, carried sufficiently deep to abolish all reflexes, without awakening the patient. As the terminal anesthetic does not have to be pushed, the throat reflex returns before the child leaves the operating table. This is an ideal technique for the removal of adenoids and tonsils in children. Nembutal

in proper dosage, also gives satisfactory results in adults.[8]

Evipal soluble administered *rectally* has proved safe and most satisfactory in producing quiet sleep in adults. This preliminary medication may be supplemented by the rectal administration of one or two ounces of ether and an equal amount of oil. It is usual to supplement this in the operating room by ethylene and oxygen, or ether and oxygen. For prolonged operations, plastic or brain surgery, nothing is more satisfactory than ether and oil by rectum, supplemented *intermittently* by small amounts of anesthetics by inhalation when necessary.

The idiosyncrasies that sometimes appear following the administration of local and spinal anesthetics will be suppressed or very greatly diminished by the administration of some barbiturate as a preliminary medicament in local, spinal, or inhalation anesthesia. Evipal soluble by rectum is recommended as perfectly safe, since the difference between the anesthetic and the toxic dose in this method is 4 plus or greater than any anesthetic agent or method in general use today.

"Lathesia." The most recently employed preliminary medication is a mixture of ether in pure caoutchouc. This combination reduces by less than one-half the bulk usual with equal amounts of ether and oil. It is similar to vaseline, but more liquid, and comes readily prepared in desired amounts in collapsible tubes with rectal adapters. The tubes and adapters are thrown away after use. The material is stable, the latex acting as a stabilizer and anti-oxidant.

In the pharmacologic laboratories of New York University Dental School, Professor Neuwrith, parallelling the experiments of the late Professor Charles Baskerville,[11] proved by laboratory experiments that ether evaporates from "lathesia" evenly, as it does from oil, at body temperature. Clinically, it apparently acts in the same manner as does the ether and oil mixture. It is much easier to give and much

CHART I
(By E. R. Plumb, Anesthetist)

Operation June 1937	Age	Wt.	1½ Hours Prenp. Hypo.	1¼ Hours Preop. Amount Rectal Evipal	Sleeping after Evipal	1 Hour Preop. Amount Rectal Lathesia	Terminal Anesthesia	Blood Pressure		Relaxation	Postop. Nausea	Remarks
								Pre-op.	Post-op.			
Repair of rectocele and cystocele	47	117	Magendie m. 7	3 Gm.	8 min.	0	$C_2H_4 + O_2$	148/94	140/80	Satisfactory	Nnne	Reacted in 1½ hours. Metrazol 2 c.c.
Hysterectomy	47	170	"	3 Gm.	4 min.	ℨ ñ	Nnne	128/88	120/84	Excellent	None	Reacted quietly in 4 hours. Metrazol 2 c.c. Resp. 8–12 during op.
Appendectomy, uterine suspension, bilateral salpingectomy	28	170	"	3 Gm.	5 min.	ℨ ñ	$C_2H_4 + O_2$ for closing of abdomen	138/98	128/90	Excellent	None	Op. postponed 1 hour, 40 minutes. Reacted 3½ hours quietly. Metrazol 2 c.c.
Appendectomy	26	133	"	2 Gm.	12 min.	ℨ ī	$C_2H_4 + O_2$	128/88	120/84	Excellent	None	Reacted quietly 2 hours. (?) Metrazol 2 c.c.
Resection of portion left ovary, appendectomy	50	136	"	2 Gm.	8 min.	ℨ ī	$C_2H_4 + O_2$	145/95	140/100	Excellent	None	Reacted quietly 5 hours. (?) Metrazol 2 c.c.
Resection of parotid cyst	59	148	"	0	0	ℨ ṽ	$C_2H_4 + O_2$ for a few minutes to control cough reflex	168/110	168/110	Excellent	Nnne	Reacted quietly 1½ hour
Repair of rectocele and cystocele	54	160	"	3 Gm.	10 min.	0	$C_2H_4 + O_2$	128/88	136/90	Satisfactory	None	Reacted quietly Time (?) Metrazol 2 c.c.
Hysterectomy, excision of ovarian cyst	40	164	"	3 Gm.	4 min.	ℨ ī	$C_2H_4 + O_2$	124/88	120/80	Excellent	None	Reacted quietly 45 min. postoperatively. Metrazol 2 c.c.
Hysterectomy	48	138	"	2 Gm +	8 min.	ℨ ñ	None	118/78	124/80	Very good	Vomited once	Reacted quietly 2 hours 15 minutes. Metrazol 2 c.c.
Ventral suspension, appendectomy	34	132	"	2 Gm.	11 min.	ℨ ñ	$C_2H_4 + O_2$	128/74	120/80	Very good	None	Reacted quietly 2 hours 45 minutes. Metrazol 2 c.c.
Excision ovarian tumor March '37	37	128	"	2 Gm.	12 min.	ℨ ī	$C_2H_4 + O_2$ + Ether	104/60	112/68	Very good	None	Reacted quietly. Time?
Uterine suspension March '37	28	120	"	2 Gm.	8 min.	ℨ ī	$C_2H_4 + O_2$	118/80	124/8n	Very good	None	Reacted quietly. 25 minutes.
Vaginal plastic March '37	30	140	"	3 Gm	6 min.	0	$C_2H_4 + O_2$	104/58	100/60	Very good	None	Metrazol 3 c.c. Reacting at end of operation
Sturmdorf operation March '37	40	136	"	3 Gm.	4 min	0	$C_2H_4 + O_2$	148/100	140/92	Very good	None	Metrazol 3 c.c. Reacted quietly. Time?
Lorenz Butsch operation	70	120	Magendie sol. m. 5	15 Gm	10 min	0	$C_2H_4 + O_2$	140/88	132/90	Very good	None	Reacted in op. room

These cases do not always follow the above schedule as to time evipal and premedication were given, but where it is possible to do so they are kept to this schedule. Metrazol 3 c.c. is now used routinely. E. R. Plumb, Anesthetist.

more pleasant for the patient to take the same amount of ether in "Iathesia" than when mixed with oil. The latex is in no way altered by the body chemistry or temperature and is considerably less expensive than the full oil-ether mixture. In the large quantities used, this means a saving of thousands of dollars. Latex is not absorbed, but is expelled by the next bowel movement. Chart 1 gives for the first time a report of the use of "Iathesia" in surgical operations. As ether per rectum practically eliminates nausea and vomiting, this new method of administration will greatly popularize ether as a therapeutic measure in whooping cough and other diseases, as a supplement to rectal evipal and avertin, or as a preliminary or complete anesthetic.

SUMMARY

It is now a common practice in some clinics to give oil-ether, evipal, nembutal, avertin, or some other drug in order to avoid the possibility of lung lesions and psychic reflexes and the unpleasant experiences usual with a patient anticipating and dreading the unknown, regardless of the terminal anesthetic or method of administration.

Both morbidity and mortality can be decreased by the universal use of a safe preliminary medication. Preliminary medication is practically synonymous with safety to life in anesthesia.

The 120 deaths listed by Dr. Henson as occurring within an hour or so after the induction of anesthesia would be prevented when and if the suggestion of the American College of Surgeons is accepted by hospitals and medical colleges.

"Ether" deaths are unnecessary, and simply mean that internes without adequate knowledge or instruction are giving anesthetics as one of their first duties on or before leaving college. Albert Miller[10] has shown that ether is safer than nitrous oxide

as regards both morbidity and mortality *when the anesthesia is in the hands of qualified anesthetists.*

Experience has proved that when a patient is returned to bed, asleep after an operation, he should be turned from side to side every hour in order to secure free ventilation of the lungs. An airway tube should be left in situ until the reflexes return.

Nearly all anesthetic deaths, as such, are avoidable, provided the anesthetist is properly trained and has the necessary equipment.

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APNEA DURING ANESTHESIA*

THE RELIEF OF ANOXEMIA AS A POSSIBLE CAUSE

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IT is generally stated that under physiologic conditions apnea is largely due to excessive elimination of carbon dioxide from the blood. That other factors are concerned in the control of respiratory activity is well established. Afferent impulses from various parts of the body influence the activity of the respiratory center. Reflexes from the lungs stimulated by respiratory movements and those arising from the carotids and aorta due to changes in the chemical composition of blood are essential to respiratory control.

During anesthesia normal physiologic conditions of respiration are always disturbed. The physical condition of the patient that prompts surgical intervention is frequently a factor and the depressant drugs used for anesthesia as well as the technique by which they are employed always contribute to the alteration. Not infrequently the derangement of normal function is manifested by a depression of the activity of the respiratory center to the extent that respiratory movements cease or apnea results. In the advent of such apnea it is extremely difficult to assess the influence of the various factors that may be involved, and consequently, it is perplexing for the anesthetist to decide upon the proper procedure to prevent deleterious results. If the apnea is attributed to excessive elimination of carbon dioxide from the blood and treatment is attempted by forcing carbon dioxide into the lungs, serious consequences will frequently follow. However, if treatment of apnea is based upon the known fact that the accompanying anoxemia will in a very short time damage the heart and brain, then oxygen will be forced into the lungs and the possibilities of unfavorable results are minimized.

During clinical anesthesia, phenomena may be observed which lead to the deduction that increasing the oxygen tension of the inspired atmosphere depresses respiration or causes apnea. Specific examples of some such incidents are cited, together with a brief discussion of the possible mechanism involved. It is our purpose to point out that such apneas are due to an error in anesthetic technique. Although the oxygen concentration of the inspired atmosphere is increased at the time apnea occurs, the treatment includes maintaining a relatively high alveolar oxygen tension.

CASE I. J. S., male, aged 40. Operation: Sacroperineal resection of rectum. Preanesthetic medication: morphine sulphate gr. ¼ (0.016 Gm.) and scopolamine gr. 1/150 (0.00048 Gm.) administered subcutaneously.

Anesthesia was begun one and one-half hours later with cyclopropane, using a closed system with a unit to absorb carbon dioxide. Approximately 1,500 c.c. of oxygen was introduced into the breathing bag, then cyclopropane was added at a rate of 500 c.c. per minute, together with 1,200 c.c. of oxygen per minute. After three minutes, cyclopropane was discontinued and the oxygen flow maintained at 400 c.c. per minute. Two minutes later, respirations ceased. The pulse was found to have diminished in rate from 100 to 60 beats per minute and the blood pressure recorded a slight change from 110/70 to 100/60. Apnea persisted for three minutes until the anesthetic mixture in the rebreathing

bag was partially replaced by nitrous oxide and introduced into the lungs by positive pressure. Breathing then resumed at a rate of 20 respirations per minute, but the patient was slightly cyanotic. The sudden introduction of a blast of oxygen in the anesthetic mixture resulted in respiratory arrest lasting four minutes or until relieved by the administration of nitrous oxide. Apnea occurred again fourteen minutes later and an attempt to correct it by removing the canister of soda lime from the system for five minutes, with consequent increase in the carbon dioxide concentration, was futile. When the oxygen concentration was reduced, spontaneous respirations were immediately restored and maintained at the expense of evident sub-cyanosis. Twenty minutes later apnea was again demonstrated. The anesthetic mixture in the breathing bag was eliminated and a mixture of 1,000 c.c. of oxygen with 200 c.c. of cyclopropane flowing per minute was administered for two minutes, whereupon respiration ceased. Spontaneous breathing was not resumed until the oxygen concentration was reduced by addition of nitrous oxide.

At the end of the operation, when the anesthetic apparatus was removed, pure oxygen was added to the inspired atmosphere by holding a rubber delivery tube with oxygen flowing 8 to 10 liters per minute, over the patient's nose and mouth for several seconds and this once more caused an apnea of two minutes' duration.

CASE II. J. M., male, aged 28, suffering from tuberculous peritonitis, was scheduled for exploratory laparotomy. Preanesthetic medication, consisting of morphine sulphate gr. $\frac{1}{6}$ (0.010 Gm.) and scopolamine gr. $\frac{1}{150}$ (0.00048 Gm.), was administered at 10:30 A.M. and repeated, by error, at 11:00 A.M.

At 11:45, anesthesia was induced with cyclopropane and oxygen. After several breaths apnea occurred. Artificial respiration by pressure on the breathing bag was begun and maintained. After fourteen minutes spontaneous respirations returned, first at a rate of six per minute but gradually increasing in frequency during the next half hour until they reached twenty per minute when the operation was completed. Blood pressure and pulse alterations were insignificant throughout the operation. First plane surgical anesthesia was maintained with satisfactory abdominal relaxation.

CASE III. J. A., a boy of 7 from the tuberculosis service, developed acute appendicitis. Appendicectomy was urgently proposed. Morphine sulphate gr. $\frac{1}{10}$ (0.006 Gm.) and atropine sulphate gr. $\frac{1}{300}$ (0.00024 Gm.) were administered for preanesthetic medication at 12:45 P.M., and because of an error the same amount was given at 1:30 P.M. The child received a total of morphine sulphate gr. $\frac{1}{5}$ (0.012 G.) and atropine sulphate gr. $\frac{1}{150}$ (0.00048 Gm.).

Induction of anesthesia was accomplished, using cyclopropane with a high oxygen dilution by the carbon dioxide absorption technique. At the end of two minutes the patient's respirations ceased. Artificial respiration was instituted, but after five minutes apnea still persisted. The carbon dioxide absorber was then removed from the rebreathing system and artificial respiration continued for five minutes allowing carbon dioxide to accumulate in the rebreathed mixture. Spontaneous respirations did not occur. The pulse rate and rhythm were little changed and active eyeball motility established the degree of narcosis in light surgical plane. At 2:35 P.M., 1.5 c.c. of metrazol was injected subcutaneously and artificial respiration continued. At 2:45 the patient reacted, opened his eyes, moved his head and breathed spontaneously at a rate of twenty per minute. Cyclopropane with excess oxygen was reintroduced and five minutes later apnea occurred again for four minutes. Breathing then resumed, at first shallow, at a rate of ten respirations per minute, gradually becoming deeper, and finally reaching a rate of twenty-two per minute at the end of operation.

CASE IV. L. R., male, aged 74, was scheduled to have a suprapubic cystostomy. Morphine sulphate gr. $\frac{1}{6}$ (0.010 Gm.) and scopolamine hydrobromide gr. $\frac{1}{150}$ (0.00048 Gm.) were administered at 12:40 P.M. At 2:00 P.M., upon arrival at the operating room, the patient was markedly depressed, as evidenced by stupor, pin-point pupils, and sub-cyanosis. He reacted sluggishly to pain and to loudly spoken questions. Respiration appeared normal at a rate of twenty-two per minute, of fair amplitude, with intercostal and abdominal activity both present. The pulse rate was 108. Infiltration anesthesia was used. Before operation pure oxygen was administered in a closed system with the carbon dioxide absorber in place. The patient's color rapidly improved and the pulse

rate slowed to 100. Respirations became decidedly shallower and intercostal activity was lost although the rate changed only from twenty-two to twenty per minute. This status was maintained for five minutes. Upon discontinuing the oxygen, respirations deepened, the rate increased to twenty-four per minute and intercostal muscles became active. The pulse rate returned to 108 and subcyanosis recurred. The operation was then quickly performed under local anesthesia.

At its conclusion the patient was still stuperous. Metrazol 1.5 c.c., injected intravenously with a similar amount intramuscularly, elicited an immediate response. The patient became more alert and could understand spoken questions. In bed ten minutes later, the patient was in a state of tonic contracture with occasional generalized tremors. Nasal oxygen and an intravenous infusion were started. At 5:00 P.M., he was irrational and apprehensive, necessitating restraint. At 10:00 P.M. he was still restless and mentally confused. Oxygen therapy was continued during the night. In the morning the patient seemed normal, cheerful and coöperative. Recovery was progressive without evidence of any effect from the experience.

Three cases are here reviewed in which patients received excessive premedication with morphine and scopolamine or atropine, and exhibited apnea during cyclopropane anesthesia. During cyclopropane anesthesia with the technique in use here, the concentration of oxygen in the alveolar air is more than 30 per cent.[1] These apneas were not due to an anesthetic overdose, since in the first case spontaneous respiration was restored by the administration of nitrous oxide. Artificial respiration with pure oxygen for several minutes did not relieve the apnea. The apnea was not due to acapnia since it could be produced without carbon dioxide absorption, that is, by using a closed rebreathing system for five or more minutes so that the carbon dioxide content was increased by accumulation of the carbon dioxide exhaled. Since the return of spontaneous respiration following the administration of nitrous oxide was always accompanied by cyanosis and since attempt to relieve this cyanosis by increasing the oxygen content resulted in respiratory arrest it was evident that respiratory activity in these cases was, in a large part at least, dependent upon some degree of anoxemia. Similar reactions are observed under nitrous oxide anesthesia where suddenly increasing the oxygen after marked cyanosis has developed frequently results in short periods of apnea.[2] Another case (IV) demonstrates that when morphine is given in a quantity sufficient to cause stupor and sub-cyanosis, the inhalation of atmospheres rich in oxygen may cause further depression of respiration, as evidenced by a decrease in respiratory amplitude and by a loss of intercostal activity in one subject.

In the experimental animal the mechanism for the production of this oxygen depression has been demonstrated.[3,4] When morphine and barbiturates are given, alone or combined, in doses sufficient to cause respiratory depression and anoxemia, the administration of oxygen results in increased respiratory depression or apnea and respiratory failure. The addition of 5 to 10 per cent carbon dioxide to the inspired atmosphere does not prevent this phenomenon. It has been shown that the animals receiving large doses of barbituric acid derivatives and morphine maintained respiration by an anoxemic stimulus acting through the sino-aortic mechanism and that the administration of oxygen which relieved anoxemia resulted in hypopnea or even apnea.[4]

Similar results have been noted in rats where cyanosis and asphyxial symptoms occurred following the injection of large doses of sodium iso-amyl ethyl thiobarbiturate. In such cases, the animals treated with oxygen two to five minutes after the appearance of respiratory difficulty recovered, but those in which cyanosis and dyspnea had persisted for more than a half hour, oxygen inhalation resulted in shallower respiration followed by periods of apnea and finally death.[5] In the dog, reactions similar to those observed in the first two clinical cases have been recorded here. Animals were premedicated heavily with morphine and

atropine, then anesthetized by cyclopropane and oxygen, using the carbon dioxide absorption technique. Shortly after anesthesia was established respirations would cease. This apnea could be immediately relieved by the addition of nitrous oxide or nitrogen sufficient to cause cyanosis and again reproduced by adding oxygen.

When the respiratory center is depressed the hypoxemia which follows is an effective stimulus to receptors in the carotid body which in turn stimulate respiration and increase pulmonary ventilation.[6] This anoxemic hyperpnea is mainly or entirely reflex and should not be confused with the hyperpnea of carbon dioxide and acid excess which is more central than reflex. In contrast to this reaction in the intact animal, in those with the vagi divided and the carotid sinus denervated anoxia causes depression of respiration.[7] Although there is clinical and laboratory evidence to show that oxygen may produce respiratory depression, it is not oxygen in itself that causes this phenomenon. It is due to excessive use of depressant drugs for preanesthetic medication and anesthesia. These inhibit the activity of the respiratory center which is much more sensitive to their depressant effects than is the reflex mechanism arising in the carotid body. Oxygen lack is the only effective stimulus to the carotid body receptors and when it is removed by the inhalation of oxygen at a time when the center is depressed, apnea or depression of respiration will result.

From the practical viewpoint, the treatment of this type of respiratory depression is important. Prophylaxis primes all and the importance of avoiding a combination of drugs that lead to severe depression, cannot be over-emphasized. In this regard, it should be remembered that anesthetic agents are central depressants. Greater depression may be anticipated with the more potent agent and consequently, when they are employed, less preoperative sedation is advised. With cyclopropane, a potent anesthetic gas which does not stimulate but frequently depresses respirations, one-half the usual morphine premedication has been recommended.

Also the relation between preanesthetic medication and the metabolic activity of the patient should be well considered. When a patient, inadvertently over-premedicated, manifests respiratory arrest under anesthesia in which the oxygen concentration is greater than in the normal atmosphere, the correction of this condition should aim at overcoming the cause of the disturbance, namely, the depressed respiratory center and the anoxia.

It should be remembered that depression of the respiratory center by anesthetic drugs is aggravated by a poor supply of oxygen. Any reduction in the oxygen content of the breathing system until spontaneous respiration is reëstablished while cyanosis appears is unphysiologic and adds further damage to the brain and heart. It may, in a very short time, produce permanent cerebral damage through prolonged oxygen lack.[8] In the cases described, nitrous oxide was not employed as a desirable remedy, but rather to demonstrate that respiration was induced by anoxemia. When it is determined that respiration ceases upon increasing the oxygen content and reappears under cyanosis, it should indicate that the respiratory center is inefficient. Rather than to continue this vicious circle, effort should be maintained to overcome this depressive state by persisting in the administration of oxygen together with artificial respiration until the respiratory center regains its normal activity. Case II illustrates the effectiveness of this principle.

The use of carbon dioxide is especially to be condemned. When the respiratory center is severely depressed, increasing the carbon dioxide tension in the inspired atmosphere will usually cause further depression or failure of respiration. If the concentration of carbon dioxide added is excessive it may increase the depression from its own anesthetic action.[9] If some stimulation results from carbon dioxide, it serves only to increase the cell oxygen

requirements and unless oxygen is also increased, a bad situation is made worse.

Central respiratory stimulants may possibly be used with advantage in conjunction with oxygen treatment and artificial respiration. During depression due to morphine overdosage pentamethylene tetrazol (metrazol) is often of value as an analeptic.[10] It may be employed postoperatively when it is observed that, due to the morphine, recovery from anesthesia is unusually prolonged. It may be administered during the course of anesthesia or preoperatively when central nervous depression from preanesthetic medication is evident. Analeptic therapy does not preclude oxygen therapy with which it should always be combined. This is well illustrated in the last case where the respiratory and cerebral stimulation produced by metrazol did not prevent the development of anoxemic symptoms (generalized tremors, irrationality, apprehension and restlessness) which diminished and disappeared following prolonged oxygen administration.

Case IV also emphasizes the importance of early and prolonged treatment. When drugs have been administered that depress the respiratory center to the extent that respirations are carried on mainly by an anoxemic stimulus to the carotid body, treatment is urgently indicated. The administration of oxygen should not be delayed until inhalation anesthesia is inaugurated. It is equally important that treatment be continued after surgery is completed.

SUMMARY

1. Observations of clinical cases are presented which corroborate the experimental findings that when central respiratory depression and anoxemia are present the administration of oxygen may further depress respiration to the point of respiratory arrest.

2. When the two conditions, depressed respiratory center and anoxemia, exist, respiration is carried on mainly by an "anoxemic stimulus" mediated through the carotid body.

3. Morphine medication is a frequent factor in causing central respiratory depression with ensuing hypoxemia resulting in respiratory activity maintained by an "anoxemic stimulus." Further addition of an anesthetic agent enhances the central depression so that the administration of high concentrations of oxygen may produce apnea by removal of the "anoxemic stimulus."

4. To avoid such apnea during anesthesia, it is recommended that preanesthetic morphine be reduced when a potent non-irritating anesthetic agent like cyclopropane and excess oxygen is to be used.

5. When such apnea does occur it is suggested to maintain high oxygen concentration and employ artificial respiration until spontaneous respiration is resumed. During such apnea the use of carbon dioxide is not advised. A central respiratory stimulant, such as metrazol, may be useful in conjunction with oxygen therapy.

6. When respiratory activity is maintained largely by an anoxemic stimulus by way of the carotid body, treatment with oxygen is indicated to prevent cerebral damage from oxygen want.

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FRACTURES OF THE HUMERUS*

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THE treatment of fractures of the humerus entails difficulties which are well recognized. Most of the standard texts present several methods of treatment for each variety of fracture, a lack of unanimity which testifies to the absence of a uniformly satisfactory procedure. Reduction of the fracture is usually not difficult, but satisfactory maintenance of position is often a problem. It is the purpose of this paper to present, or rather to restate, a method of fixation by traction which has proved successful in a large series of cases. With a few rare exceptions, the method is applicable to all varieties of fracture of the humerus. The advantages claimed are: (1) simplicity; (2) comfort; (3) universal applicability to all patients who can assume the erect position; and (4) anatomic and functional results superior to those obtained by other methods or combinations of methods.
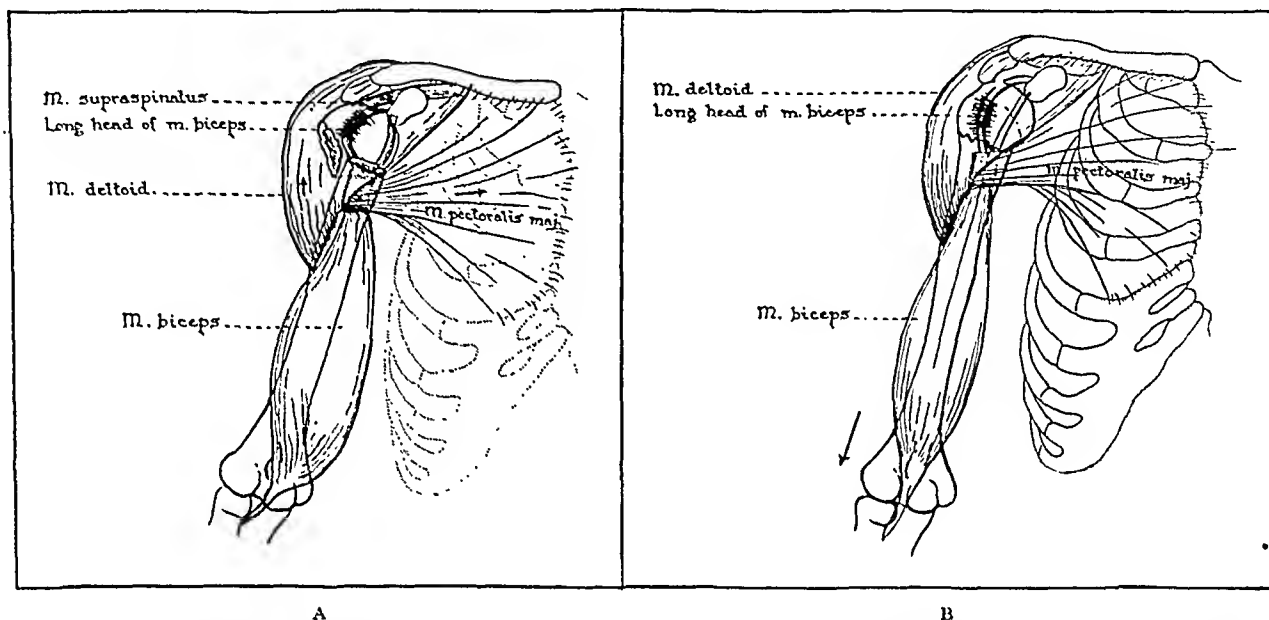
FIG. 1. A, the forces causing displacement in fractures above the pectoralis. The head is controlled chiefly by the supraspinatus, which is the most powerful muscle attached to it. The distal fragment is pulled inward by the pectoralis and upward by the deltoid and longitudinal muscles. The long tendon of the biceps lies loose in the bicipital tunnel. B, the result of traction parallel with the body. The taut biceps tendon rolls the head into position, and holds it there.

The fundamentals involved are not new, but have been submerged in a flood of abduction plaster casts, aeroplane splints and intricate procedures for recumbent traction or internal fixation. In principle the method converts the forearm into a lever with the fulcrum at the wrist and force exerted in the line of the humerus. To accomplish this end, the wrist is supported by a sling, and a plaster cast maintains the elbow at a right angle. The cast, plus the unsupported portion of the arm and the forearm, supplies the necessary traction weight. (Fig. 4.) Many of the older texts illustrate this principle with drawings showing the wrist supported

by a sling, and traction applied by a weight suspended from the elbow. Caldwell[1] introduced the plaster cast to supply traction

anteriorly and drawn medially by the pectoralis. (Fig. 1A.)

The old dictum that the distal fragment
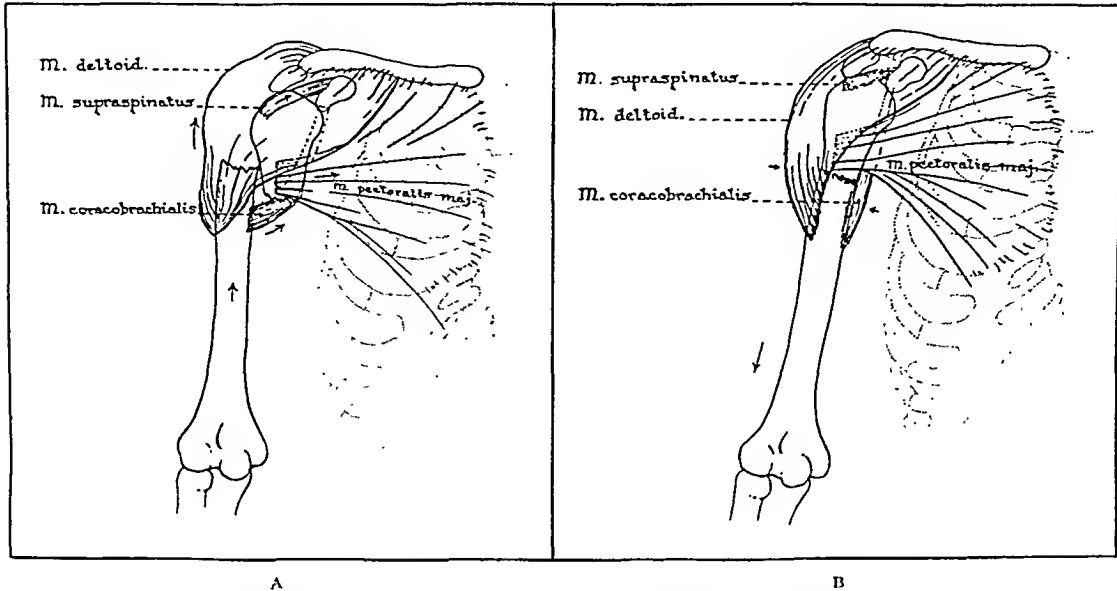
FIG. 2. A, typical displacement in fracture between the pectoralis and deltoid. B, the effect of traction. Tension on the longitudinal muscles results in a squeezing effect at the fracture site.

and to control the elbow and distal fragment.

For purposes of treatment, fractures of the humerus may be divided as follows:

1. Those above the insertion of the pectoralis major.
   (a) Fractures of the head and tuberosities.
   (b) Fractures of the surgical neck.
2. Fractures of the shaft.
   (a) Fractures between the insertions of the pectoralis and the deltoid.
   (b) Fractures of the shaft below the deltoid.
3. Supracondylar and condylar.

Slight variation in details of treatment must be made for each class.

Fractures above the Insertion of the Pectoralis Major. In these fractures the short upper fragment is controlled by the muscles attached to it. The most usual displacement of this fragment is flexion and rotation. Abduction of the short fragment is not so commonly encountered as the wide preference for treatment in abduction would indicate. The shaft fragment is most often displaced

must be placed in line with the proximal one may be disregarded. The only reason for this rule is that the proximal fragment is supposedly not under our control. Howard and Eloesser[2] have shown that the intact long tendon of the biceps gives adequate control of the short fragment when traction is applied parallel to the body. This tendon, lying in the tunnel formed by the bicipital groove and its fibrous covering, swings the head into position parallel with the body, correcting abduction and flexion or extension. Rotation is taken care of by the tendon and by placing the forearm across the body. (Fig. 1B.) Traction parallel to the body requires much less pull to maintain reduction than traction in abduction. In the abducted position most of the traction force is wasted in pulling against the powerful pectoralis major, teres major and latissimus dorsi. Three or 4 pounds in adduction is the equivalent of 15 or 20 pounds in abduction.

Reduction of the fracture is carried out under local or general anesthesia by the maneuver of Cotton and Morrison[3] or
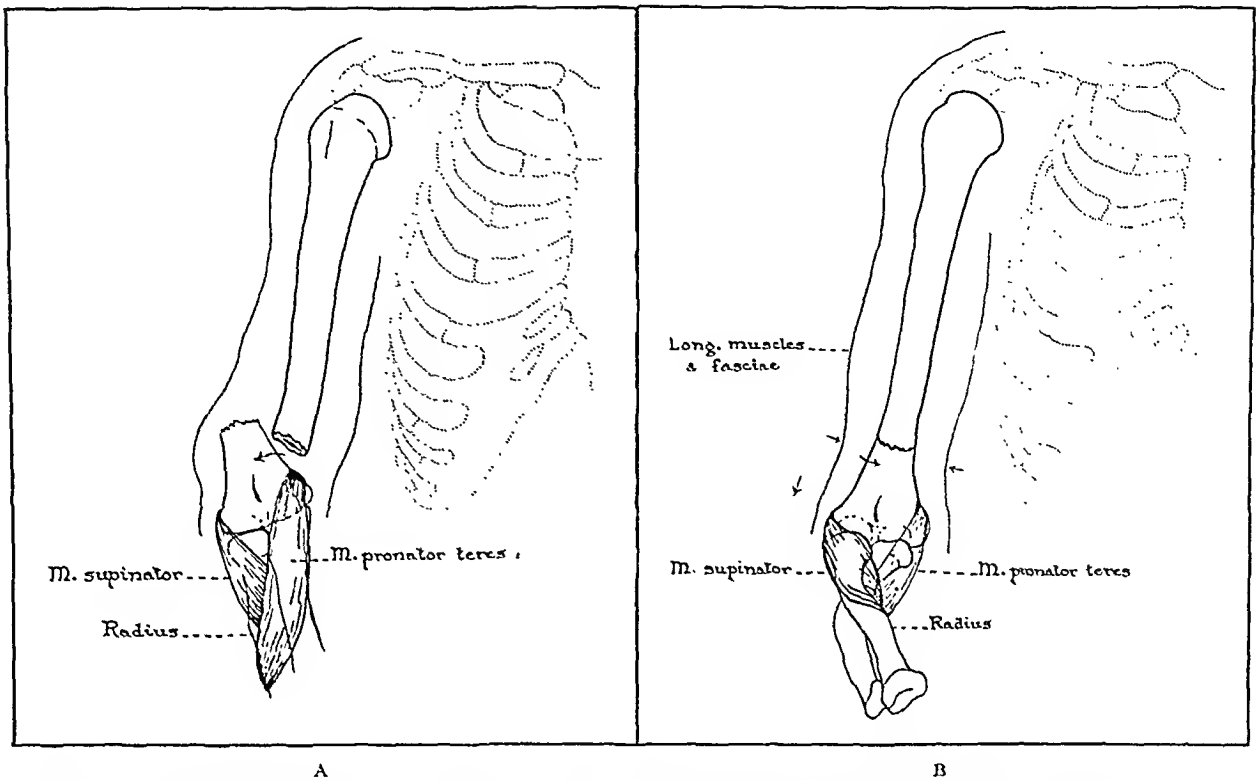
FIG. 3. A, varus deformity in supracondylar and low shaft fractures. Since the elbow is fixed in full prona-
tion, supination (varus) occurs at the fracture site, not at the fixed elbow. B, full pronation swings the
distal fragment into correct alignment. Longitudinal muscles and fascia, pulled taut by traction, exert
squeezing pressure on the fracture.

FIG. 4. The traction cast in place. Note the
right angle at the elbow and the horizontal
position of the forearm. The cast extends
over the metacarpals to prevent wrist
drop.

FIG. 5. The position assumed for circumduc-
tion exercise of the shoulder. The arm
swings free and is actively moved from the
shoulder in all directions.

by that of Howard and Eloesser.[2] We prefer the former. A traction cast of 3 to 4 pounds in weight is applied immedi-

suture of the tendon or fixation of the head[4] are then the methods of choice.

Fractures of the Shaft. Fractures in
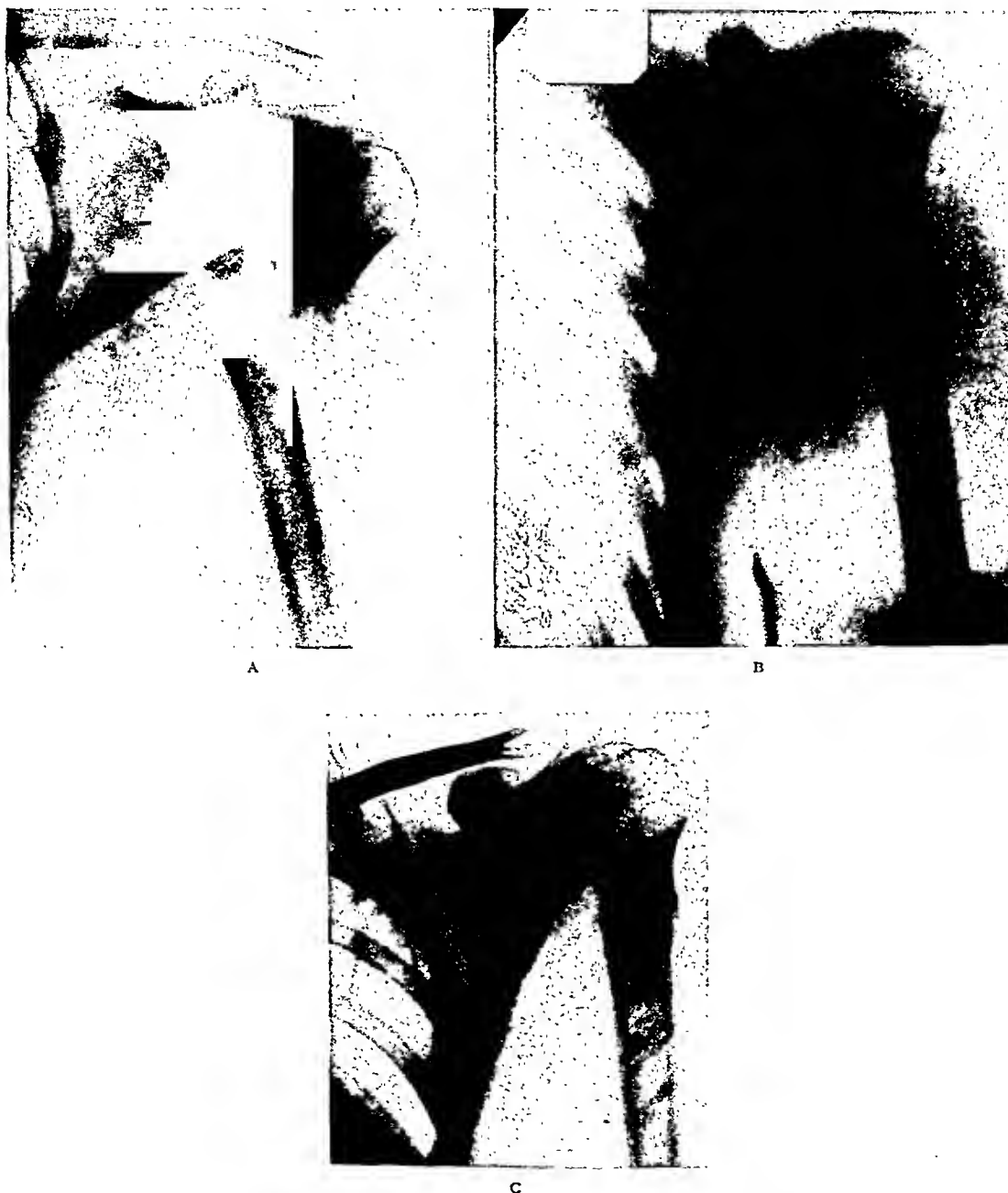
FIG. 6. A, typical fracture above the pectoralis (patient supine). B, immediately after reduction and application of cast (patient erect). C, the same fracture at the end of two months.

ately with the elbow at a right angle and the forearm in mid-pronation. In the rare case with rupture of the long head of the biceps, these maneuvers will fail to reduce the fracture, and open reduction with

the small space between the pectoralis and the deltoid are rare. The proximal fragment is usually pulled medially by the pectoralis and the distal fragment upward and outward by the deltoid.

A   B
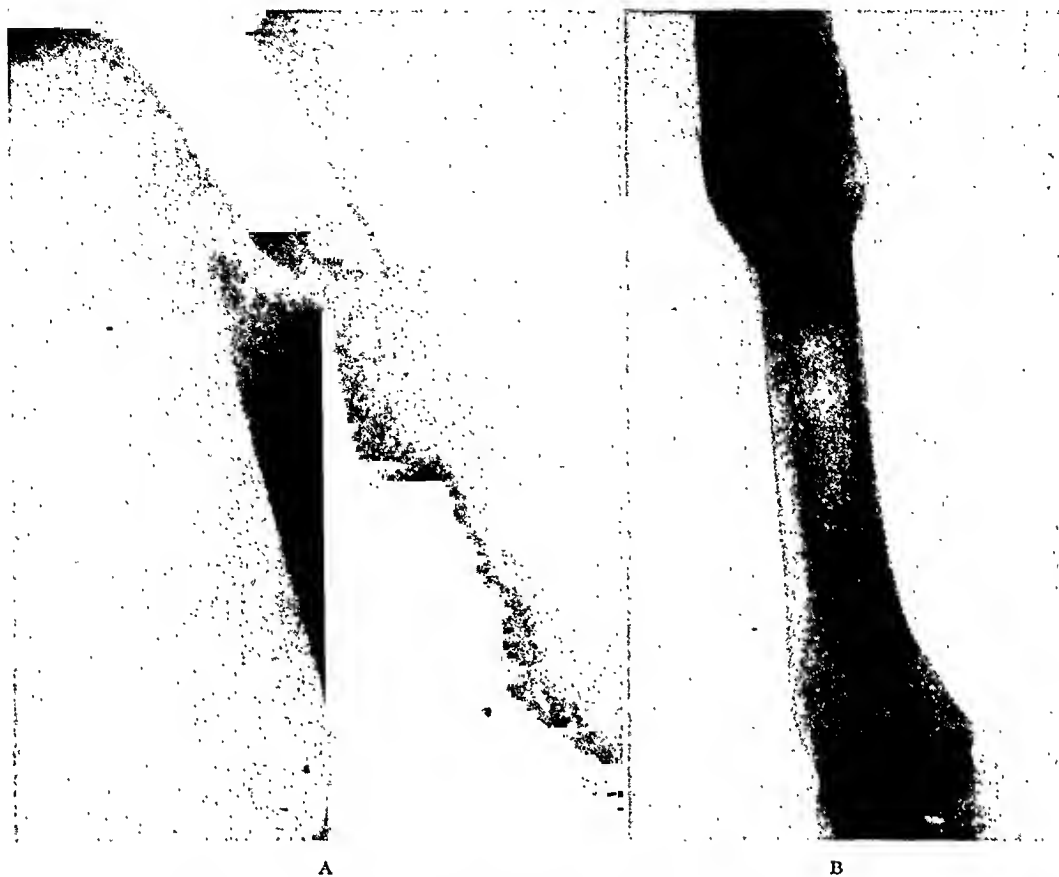
FIG. 7. A, typical fracture of the midshaft immediately after application of cast. X-ray taken in supine position, so that fracture is not in position. B, the same fracture healed in good position with large callus.

A   B

FIG. 8. Lateral views of same case as in Figure 7.

(Fig. 2A and B.) Fractures below the deltoid have no typical displacement except in the distal portion of the shaft,

Varus deformity occurs in fractures low in the shaft and in the supracondylar region. Because of the break in continuity

FIG. 9. A, gunshot fracture of lower third of shaft showing typical varus deformity. Treated in full pronation in traction cast. B, the same fracture fifty-four days later. Good position and normal degree of healing.

where a varus deformity may exist as in supracondylar fractures.

Local anesthesia is used for fractures of the shaft, and gross reduction is obtained by manual traction and manipulation. The traction cast completes reduction just as suspension-traction methods reduce fracture of the shaft of the femur. Under the influence of traction the taut fibromuscular structures about the bone squeeze the fragments into place. The cast should not weigh over 3 pounds, especially in transverse fractures, which may be easily distracted by a heavy cast. In many transverse fractures it is sufficient to apply a "sugar tong" coaptation splint of plaster, extending from the axilla, around the elbow and up to the insertion of the deltoid. The wrist is suspended by a sling. The unsupported portion of the arm and forearm supplies sufficient traction force.

of the humerus the strong supinating action of the biceps is lost. The elbow joint comes under complete control of the strong pronators and is held in full pronation. Attempts to place the forearm in even slight supination result in supination (varus deformity) at the fracture site, since the joint is fixed by the pronators. (Fig. 3A and B.) Supracondylar and low shaft fractures are therefore placed in full pronation during and after reduction and the cast is applied in this position.

"T" and "Y" fractures of the condyles are reduced by traction with the elbow at a right angle and the forearm pronated. At the same time bilateral pressure is applied to push the condyles together. The cast is applied in full pronation to prevent varus. The same procedure and position are used in isolated fracture of the medial condyle. Fracture of the lateral condyle, which is likely to be followed by

valgus, is fixed in full supination to prevent this deformity.

The Traction Cast. (Fig. 4.) After

A   B

Fig. 10. Lateral views of same fracture as in Figure 9.

anesthesia and reduction, a padded or non-padded plaster cast is applied from the knuckles to the axilla without regard to the site of fracture. The forearm is placed in mid-pronation unless full pronation or full supination are required, as shown above. The elbow must be at an exact right angle, so that with the patient erect and the forearm horizontal the distal fragment is vertical. A loop of wire or plaster is incorporated in the upper side of the cast at the wrist. A sling from this loop about the neck completes the dressing. The sling is placed through the loop rather than about the wrist to prevent sliding. The more distally the sling is placed the greater the traction applied to the arm and vice versa.

After-Care. The patient is instructed to remain erect as much as possible and for the first few nights should sleep in Fowlers's position. After the first week there is little possibility of displacement at night if the erect position is maintained

during the day. At first the patient must be cautioned against resting the elbow on the arm of the chair when sitting. He soon learns, however, that he is more comfortable with the elbow unsupported, so that the traction fixes the fracture. Pressure from clothing, as from a buttoned coat over the cast, must be avoided. Anything that compresses the arm against the body interferes with traction.

Circumduction exercises for the shoulder are taught and encouraged from the start. The patient leans forward and toward the injured side as far as possible, letting the arm hang free in a vertical position, the wrist still supported by the sling, and the muscles relaxed. He then swings the arm in increasingly larger circles embracing all motions of the shoulder to the limit of tolerance. (Fig. 5.) If properly carried out, this excerise will hasten convalescence and largely prevent restriction of shoulder motion. Even in fracture of the head and neck of the humerus, there is little or no atrophy of muscle.

In fractures of the shaft, care must be taken throughout the period of healing

to see that the sling is of proper length. The most common error is the use of an overly long sling. This allows the wrist to drop below the horizontal plane and swings the distal fragment of the humerus forward. Anterior bowing of the fracture then occurs. Conversely, a sling too short may cause posterior bowing.

This traction cast has been used by us in 128 consecutive cases of fracture of the humerus. Of these forty-nine were in the head and neck, sixty-eight in the shaft and eleven supracondylar and condylar. The fractures in the two extremities *of the bone all healed with joint function* superior to our previous results with any other methods. Of the fractures of the shaft all healed in good position with good function, with one exception. This patient was the brother of a physician. Open operation was carried out two weeks after fracture to remove interposed soft tissue. No internal fixation was used. Nonunion resulted, probably from reëngagement of muscle between the fragments.

SUMMARY

1. A simple effective method for treating fractures of the humerus is presented.

2. The method depends upon traction in the position of neutral muscle equilibrium.

3. It is applicable to almost all cases of fracture of the humerus.

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FACTS AND FALLACIES IN THE TREATMENT OF RECTAL CANCER

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CANCER has absorbed the attention of man from time immemorial. It has been attacked with weapons ranging from witchcraft to surgery. Great philosophers, theologists, scientists, and clinicians have devoted untold time to pondering upon it. From this vast amount of energy have sprung innumerable nostrums and a few facts.

Let us, then, forget if we can, the vast suffering which has followed the publication and practice of these various nostrums and consider how best to utilize our facts.

MARTIALLING OF FACTS

Nature of Cancer. Cancer is a change within the cell itself. It is presumably a disturbance of the intracellular chemical balance. It causes the cell to grow and multiply without consideration for its function nor for its anatomic boundaries. It enables the cell to flourish on less oxygen than is needed to preserve the viability of normal cells. It withstands transplanting readily.

Origin of Cancer. Two factors are known to be necessary to the production of experimental cancer. First, there must be an outside irritative factor. This may be physical or chemical. It must be applied over an appreciable portion of the life span of the animal. Synthesis of estrin has given researchers a quantitative and qualitative irritative agent which should greatly facilitate their labors.

The second necessary factor is an inherent susceptibility to cancer. This has been demonstrated through the inbreeding of mice by which means cancer and non-cancer strains have been developed very much in accordance with the Mendelian theory. Further, it has been possible to produce strains having not only a cancer diathesis but a marked propensity to develop cancer of certain sites.

Thus, the experimenter may apply a known quantity of an irritative agent for a known time to an animal of known cancer propensity and prophesy accurately the time and place at which a cancer will appear. This, naturally, leads to speculation as to viruses, toxins, antibodies, and immune bodies.

Growth of Cancer. Cancer grows without regard for physiology or anatomy. It spreads by continuous invasion of surrounding structures and by metastasis. Experimentally, it has been shown that growth will continue after the outside irritative factor has been discontinued unless the degree of susceptibility is extremely small. In these latter cases spontaneous retrogression and even total disappearance may be observed.

Metastasis. Cancer spreads through the vessels of the lymphatic and the blood systems. Those cells which find their way into the lymph channels are arrested at each node and can only proceed further after the gland has been severely damaged. Cancer emboli in the blood stream proceed swiftly on their course until trapped in a vessel whose lumen is too small to afford them passage. Hence, emboli from the alimentary canal are almost certain to be lodged at the portosystemic junction in the liver. Also, it is obvious that liver metastases will be more common than systemic ones from primary tumors of the digestive tract since the latter are mainly derived from cancer cells which pass via the lymphatics through the receptaculum chyli into the left innominate vein. Presumably, some metastatic emboli are thrown directly into local arteries but the results of these accidents are negligible.

UTILIZATION OF FACTS

Through study of these facts, three main forms of therapy emerge.

tunately cancer of the digestive tract, and especially of its caudad end, is radioresistant and its metastases are even more so.
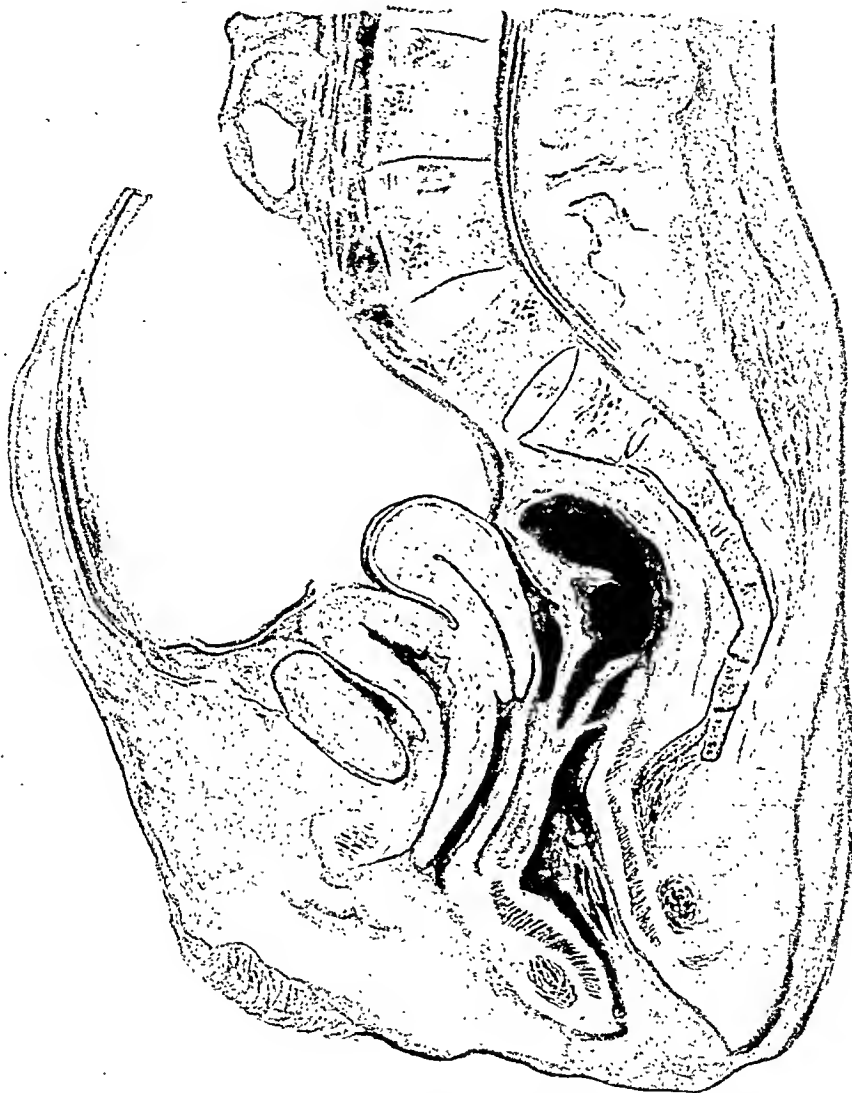
FIG. 1. Sagittal section through a child aged 14 years. Note rectal sheath and the manner in which the attachments of the levatores ani and superficialis sphincter ani facilitate its separation from the hollow of the sacrum. (From Lynch's "Diseases of the Colon and Rectum.")

First, one may attempt to produce some form of active or passive immunity. To date, no such weapon has been devised. Therefore we, as practical clinicians, must abandon this field to laboratory workers.

Second, one may attempt to destroy the cancer cell by radiation. This method depends for its success upon the fact that cancer cells are more readily destroyed by radiation than are normal cells. Unfor-

In addition, radiation of lymphatic and systemic metastases tends to produce painful sloughs, while the liver metastases cannot even be attacked. Further, the margin of safety between the dose that will destroy cancer but not normal cells is so small that horrible catastrophes occur. Radiation has been known not only to stimulate the rate of growth of a cancer but even to serve as the necessary irritant

to convert a normal cell into a malignant one.

Many "cures" are merely the arrest of immediate growth and lymphatic spread by the formation of a barrier of fibrous tissue. This of course does not prohibit metastatic emboli since these may occur so long as a single malignant cell may enter a blood vessel. Late results of this formation of fibrous tissue are the production of persistent pain and damage to adjacent organs through its contraction. These symptoms may not present themselves until years after the patient has been pronounced "cured" and treatment discontinued.

True cures of rectal cancer by radiations do occur. These are cases in which the patient's susceptibility was extremely low.

In view of these facts, we must regretfully restore this field of endeavor to the experimentalists.

Third, one may attempt to cure the condition by surgery. To this end, let us define the desiderata. They are to remove surgically all cancer cells and completely to rehabilitate the patient. Obviously, the easiest time to do this is when the growth is small and metastases have not yet occurred. Thousands of men have wasted millions of words in attempting to provide surgeons with cases of early cancer. Most cases are not diagnosed until nine to thirteen months after the inception of the growth. This is not due to the difficulty of making a diagnosis but to the absence of the opportunity for an expert to make an examination. An obvious cure is to insist upon a routine sigmoidoscopic examination biannually. This will demonstate neoplasms at a time when local removal will ensure a cure.

CHOICE OF OPERATION

However, it is the late cases of cancer about the rectosigmoid with which this paper is concerned. As to the earliest lesion which demands more than local excision, the surgeon's own good judgment must suffice. The opposite end of the scale is reached only when carcinomatosis is

present or when the patient's general condition cannot be sufficiently improved to offer any hope of surviving the opera-
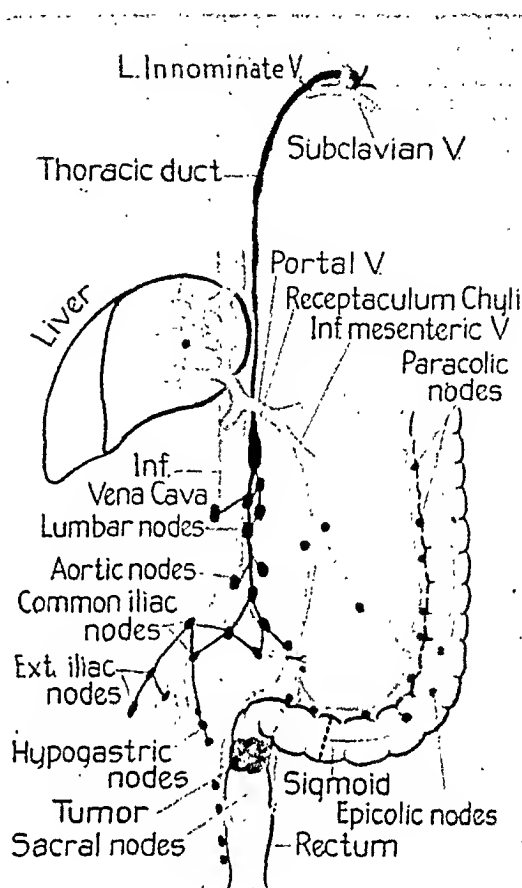
FIG. 2. Chart showing: (1) lymphatic drainage of rectum and sigmoid; (2) absence of afferent lymphatics to liver; (3) cancer cell trapped at portosystemic junction in liver; (4) dotted line indicates safe point of excision for a cancer as shown; and (5) this is the area included in our modified perineal technique.

tion. This statement is based on three facts. First, that the operability of a case can only be determined at operation. Second, removal of the primary growth obviates an imminent and painful death and at the worst converts it into a "liver death" which is distant, swift, and comparatively painless. Third, that the removal of the primary growth, in part or in toto, may permit disappearance of both primary and secondary lesions in persons of slight susceptibility to cancer.

As we have seen above, metastases are microscopic emboli which are projected

either into the blood stream or into the lymphatic circulation. Once they have entered the portal circulation they are

is pronounced since even experts frequently mistake inflammatory glands for carcinomatous ones. Cuthbert Dukes[1] found

FIG. 3. Shows similarity of the areas removed by the combined and by our own simplified technique. (From Lynch and Felsen, "Tumors of the Colon and Rectum.")

beyond the reach of any surgery. They will become trapped within the venous network of the liver and either perish or grow at about the same rate as the primary lesion. Hence we cannot diagnose the presence of metastases in the liver until many months after their occurrence when they have grown sufficiently to constitute a palpable tumor. We may, however, suspect their presence when ulceration of the primary growth is found.

For these reasons, palpation of the liver is a useless procedure and should not be allowed to affect the choice of operative technique.

Since the lymphatics are invaded in the same manner, palpation of indurated nodes can give little real information. This is true even after metastatic invasion

a 61 per cent error in the clinical diagnosis of carcinomatous glands.

However, since the course of the lymphatics draining a given area is known, an operation may be planned for excision of all those customarily affected. To this end, let us describe the lymphatic drainage of the anus, rectum and rectosigmoid briefly. The anus and lower part of the rectum drain mainly into the inguinal glands, superficial and deep, and thence through the external and common iliac nodes to the main abdominal trunk. A few channels connect with those accompanying the superior hemorrhoidal vessels.

The ampulla and rectosigmoid drain mainly into the lymphatics coursing with the superior hemorrhoidal vessels to the mesenteric nodes and thence through

subaortic and aortic groups to the cysternum chyli. The middle hemorrhoidal gland also drains this area directly into the common iliac nodes. The sacral glands receive lymph from the rectum which they pass through the hypogastric to the aortic groups of nodes. Those on the sigmoidal side drain through the epicolic and paracolic nodes to reach the inferior mesenteric group and thence through the aortic groups to the receptaculum chyli.

Metastases invade each node of a chain in turn. Very rarely, an aberrant vessel may give the impression that the invasion has skipped a gland.

Retrograde and lateral spread can occur only when a collateral lymphatic circulation has been established after complete obstruction of the normal channels.

It has been found that in cancer of the rectum few cases come to operation in which the inferior mesenteric nodes are involved. Cuthbert Dukes sectioned over 2,000 glands from 100 cases of cancer of the rectum removed by the perineoabdominal technique. He found the paracolic nodes to be invaded in only one case and that was an extremely late one in which retrograde and lateral spread had already occurred. "Skipping" also was present in one case.

Glandular involvement was present in sixty-two cases, of whom thirteen had only one gland involved, eleven, two, seven had three, and thirty had four or more glands involved.

The average distance of the cephalad involved gland from the anal margin was 21.25 cm. in twenty-four cases of Gabriel's from the above series. The superior hemorrhoidal vessels were ligated 25.4 cm. from the anal verge.

Hence it is reasonable to suppose that any operation which will remove an average of 25.4 cm. of caudad bowel together with its portion of the superior hemorrhoidal chain should give an excellent prognosis. If the operator removes the middle hemorrhoidal and sacral nodes as well the outlook becomes even brighter.

The abdominoperineal operation of Miles fulfills the first of these requirements but the second is difficult to achieve. This is because the sacral nodes lie in a plane difficult of access from the abdomen.[2] In addition, the operation is attended by a very high mortality even in the hands of experts.

The perineo-abdominal operation is a far better one. First, because the long stage of the operation is almost devoid of shock. Second because the approach facilitates the removal of the sacral and middle hemorhoidal nodes with the specimen. Third, because quite frequently the operator is agreeably surprised to find that the objective has been attained without the necessity of opening the abdomen.

This operation also has a high mortality and therefore should give way to a perineal excision of the rectum so modified as to attain the above desiderata with little danger of death. This operation has already been described.[3]

The important modifications are:

1. The incision between the tuberosities of the ischii is curved anteriorly. This allows an easier definition of the line of cleavage between rectum and anterior structures.

2. The coccyx is removed by incising its joint and rotating it backward and downward. This permits ligation of the middle sacral artery before it is damaged and before it can retract into the soft tissues. Also the attachments of the superficialis sphincter ani and the levatores ani to the cocyx and sacrum almost force one to remove the rectal sheath, with the specimen and with it the sacral nodes. If, on the other hand, the coccyx is left in situ or these muscles are cut before its removal, the line of cleavage and the sacral nodes may be difficult to define. The removal of the coccyx also provides free drainage of the wound and permits the formation of a better functioning perineal colostomy.

3. The puborectalis is used as a guide to separate the rectum from anterior structures.

4. The bowel is freed and brought down with a safe blood supply by clamping and cutting the individual vessels close to its wall. Then a ligature is placed about the pedicle of the superior hemorrhoidal vessels, and the vessels, nodes and connective tissue distal to it are removed in one piece.

5. It is sufficient to retroperitonealize the stoma and it is not necessary to bring the gut to the skin edge. The bowel eventually will find its way down to meet the skin edge. This allows the removal of that portion of the bowel which extends from the new peritoneal floor to the skin. In most cases as much bowel can be removed as with the combined technique.

6. The wound is left wide open and heals by granulation.

7. The wound is packed with gauze soaked in 10 per cent tannic acid in alcohol. This produces an albuminate strong enough to prevent saprophytic infection but not strong enough to permit virulent organisms to grow under cover of it.

8. These two procedures obviate the risk of sepsis and hence of secondary hemorrhage.

CONCLUSIONS

1. Surgery offers the only possible cure for cancer of the lower bowel today.

2. Liver metastases cannot be palpated even at laparotomy until the organ is grossly involved.

3. No lymphatics run to the liver.

4. Lymphatic spread can be predicted.

5. Abdominoperineal and perineo-abdominal operations remove no more growth nor metastases in cancer of rectum than can be removed by our technique.

6. The so-called radical operations deserve the name because of their high mortality and not because they afford a more complete excision of the growth.

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THE PREVENTION OF PAIN FOLLOWING HEMORRHOIDECTOMY*

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THROUGHOUT the years rectal surgery has enjoyed an unenviable reputation for postoperative pain and discomfort. This fear has not been entirely unfounded in the minds of laymen and physicians. To advise a rectal operation, or even a rectal examination, all too frequently brings forth a gasp of horror from the patient. Nearly every individual with a rectal disorder seems to know some one who was operated upon and endured torturing pain. The picture is not overdrawn, but the situation is no longer justifiable. This is a timely problem which presents itself to every proctologist and surgeon. The crusade for the early diagnosis and the early treatment of irritative rectal lesions is definitely obstructed by this widespread notion.

Innumerable patients have put themselves into the hands of "pile doctors" and so-called rectal sanitariums in their search for alleviation the "easy way." Many more delay treatment until their condition has become advanced or complicated.

To secure for the patient about to undergo a hemorrhoidectomy, not merely a modicum of postoperative comfort, but a painless or nearly painless convalescent period, should be the aim of every surgeon undertaking a rectal operation. This goal has been and can nearly always be achieved, provided the surgeon is ever mindful of the following elemental rules which should govern any type of surgery:

1. Close attention to certain basic surgical principles. To quote Sumner Koch:[1] "Nihil nocere—do no harm. What does 'do no harm' mean? It means, first, to avoid every form of injury, mechanical, thermal, chemical; and secondarily, not to add contamination to that which is already present. Third, to avoid so far as possible, leaving foreign bodies in the operative wound."

2. The application of that expert and particular care to which this area, as one of the most sensitive regions in the human body, is entitled.

3. The utilization of a tried and tested routine preoperative and postoperative régime.

4. The selection of an open, non-burning, non-traumatizing type of operation.

Following these tenets, I have found that post-operative pain has become the exception rather than the rule.

The skin at the anal orifice is one of the most sensitive areas in the whole body, sharing this distinction with the mouth, lips, fingers, and toes. There are two senses: one is tactile, produced by contact with the mucous membrane of the anal canal; the other is the muscle sense, which may be described as the sensation caused by the stretching action of the muscle due to something within its grip. The sensitive area is practically confined to the anal canal proper. Hemorrhoidectomy, of necessity, implies interference with this sensitive area. Almost all the sensations at the anal orifice have for their immediate object, some alteration in the state and degree of contraction of the sphincter muscle, the action of which is almost entirely reflex in character. It is, therefore, easy to understand why operations in this area are liable to result in pain, since the wounds

cause constant irritation of this reflex with consequent spasm and painful contraction of the muscle.[5]

There are surgeons who believe that they have found the answer to this problem by the use of slow absorbing, oily anesthetics. I will not say these drugs are inadequate in all cases, but it is my feeling that they are superfluous. The complications from their injudicious, and sometimes from their judicious use have not been sufficiently emphasized or even reported. To depend upon the action of a drug for an end which can be and should be achieved by exact, clean workmanship is unsurgical and unphysiologic. Since the introduction of benacol in 1927, by Yeomans[2] and his co-workers, there have been at least six or seven variations to this formula launched upon the medical market. Time and experience will relegate these foreign body substances to the rôle for which they were originally intended: for minor simple fissures and perhaps as an adjunct to the treatment of pruritus ani. I have noted that in comparing patient for patient, the healing process is retarded in the presence of these oily substances.

The steps necessary to achieve the goal of a painless or nearly painless hemorrhoidectomy convalescence must be divided into three stages: preoperative, operative and postoperative.

Twenty-four hours prior to hospitalization (unless there is some contraindication) a 6 ounce dose of citrate of magnesia will start elimination well on its way, and offset postoperative gas pains, which are so troublesome to patient and physician.

The patient should enter the hospital on the evening before the operation. A plain water enema is administered, followed by the instillation of 4 ounces of olive oil as a retention enema. This is expelled in the morning and the rectum is further cleaned with a plain water enema. All unexpelled water must be syphoned away. These procedures will usually relieve the patient of any desire to eliminate for at least three days after the operation.

The use of castor oil and other aperients on the night before the operation will cause postoperative discomfort and leakage on the operating table.

A restful sleep the night before the operation is of more importance than any other factor in reducing pre-anesthetic fears and psychic trauma. Important, too, is the rigorous insistence that the patient shall not be roused at 4 A.M. to be prepared for an 11 o'clock operation.

The use of a basic anesthetic is a matter of choice, in which the individuality of the patient must be a determining factor. In most cases 3 to 6 gr. of sodium amytal the evening before, and 3 gr. again the first thing in the morning, followed by dilaudid gr. $\frac{1}{20}$ one hour before the operation, will bring the patient to the operating room in a sufficiently relaxed condition and oblivious to the operating room activities.

A point which may seem to be minor, but is assuredly of great importance to the patient is the perianal shave. Some operators have eliminated this procedure from the routine, feeling that the subsequent bristle discomfort does not warrant its use. I still order the perianal shave. This, too, can be carried out carefully and cleanly without cutting, scratching, or tearing. It is sometimes difficult to rid this area of small hairs in the presence of large folds and skin tabs, but an experienced orderly can make this step at least endurable.

There is no justification for applying tincture of iodine or any other alcoholic antiseptic solution to a freshly shaved perineum, especially where mucous membrane may, at times, be prolapsed and exposed. Vigorous soap and water cleansing, followed by an aqueous antiseptic, such as 5 per cent mercurochrome, has proved very effective.

A factor of major importance in reducing the postoperative discomfort is the choice of anesthetic. The success of the operation depends greatly on the knowledge of the possibilities of the anesthetic procedure

employed. Certainly no general anesthetic need be employed for hemorrhoidectomy. The only possible exception to this rule might be in the presence of gangrenous strangulation. Regional anesthesia possesses decided advantage over general narcosis. The absence of postoperative vomiting, retching, coughing, and straining which are instrumental in the formation of perianal edema, skin tabs, and pain (due to strain and pulling of sphincter), and the absence of acute distention of the colon, argue for the use of regional anesthesia.

The practice of regional anesthesia is an art. It requires special knowledge of anatomy; skill in the performance of its various procedures; experience in the handling of the patient; and above all, gentleness in execution of surgical procedures.[3] The type of regional anesthetic will depend upon the patient, the experience of the surgeon, and the pathology at hand. Low spinal, local infiltration of novocaine, and caudal or sacral anesthesia, all have proponents and are all used more or less successfully.

Novocaine infiltration anesthesia will be found to fit very easily into the list of methods offering a minimum of postoperative discomfort. A thorough knowledge of perianal innervation and of the anal and perianal anatomy is required, but no more so than is required to perform skilful rectal surgery. Fifty to 80 c.c. of a one-half or 1 per cent solution, plus approximately 5 to 8 drops of adrenalin to the ounce is sufficient for successful anesthesia and sphincter relaxation. Care must be taken not to produce subcutaneous distortion, especially in the presence of external tabs, as this may lead to the injudicious removal of excess perianal skin and subsequent contraction and pain. Novocaine infiltration anesthesia can be used with any type of operative technique. If the novocaine is properly placed, the sphincter will relax almost immediately.

Operations for internal or external hemorrhoids have, for many years, been performed by means of local infiltration around the anus irrespective of the operative technique adapted. Dilatation of the sphincter, in addition to the anesthesia, is nearly always successful. The relaxation of the sphincter immediately follows the proper injection of the anesthetic solution, thus eliminating the necessity for manual or instrumental dilatation. The practice of inserting the finger into the anus so as to prevent the point of the needle from entering the anal canal and rectum, is not without risk of contaminating the healthy surrounding tissues. The finger should be inserted by all means, but a change of gloves should be made. Low spinal anesthesia, using 25 to 50 mg. of procaine hydrochloride, will afford saddle anesthesia and good sphincter relaxation. This type of regional anesthesia has been popular with the English school of proctologists. Many surgeons have questioned the feasibility of spinal anesthesia where local infiltration offers such a good substitute. The work of Davis[4] demonstrating the adverse action of spinal anesthetics on the myelin of the nerve fibers, has deterred an increasingly large number of operators from its routine use.

Sacral block anesthesia has its proponents. This is produced by subdural injection low in the spinal column. The anesthetic is used in a small dosage and is well concentrated so that the area of anesthesia remains low. Those favoring this method of regional anesthesia like its limitation to the field and the ample sphincter relaxation without distortion.

Caudal block gives almost the same results as far as operating advantages are concerned, that is, perfect anesthesia with partial sphincter relaxation. It has a marked advantage over local infiltration in that the injection is made at a distance from the operative field. The occasional failures to produce anesthesia by means of caudal block alone and the slowness with which the anesthesia sets in suggest its possible use in association with transsacral block.

A major factor in producing severe postoperative pain is the vicious and strictly uncalled for procedure of divulsing the sphincter muscle. This maneuver is by no means a thing of the past. It is carried out daily in many operating rooms. The attempt to prevent postoperative pain by stretching the sphincter ani with the idea of causing temporary paralysis, is based on a false premise. It is not successful because, unless the muscle is actually damaged, the paralysis is too transient, not lasting more than thirty minutes in most cases and often not that long. The reason for this is that the muscle, in the process of recovering its powers of contraction, will contract spasmodically, causing sudden violent pain each time the spasm occurs. One must think of the intramuscular bleeding that occurs when the sphincter muscle fibers are torn. I say torn, because no matter how gently this muscle is dilated, some of the annular fibers at least are bound to give way. I have witnessed the insertion of one finger after another into the anal canal until nearly the entire hand passed through the orifice. This procedure, while not as frequent with local anesthesia, is still carried out routinely by a surprisingly large number of operators.

Even when the thumb and forefinger are inserted, a great deal of spasm results because of the unmeasured and unrealized force used. All theories upholding sphincter divulsion are purely hypothetical. The fact remains that patients operated on without preliminary divulsion are many times happier and more comfortable than are those in whom divulsion is carried out. The mechanical divulsor which, strangely enough, is seen in many operating rooms of modern hospitals has been the cause of partial incontinence.

It would be difficult to find two surgeons performing a hemorrhoidectomy in the same manner. Indeed, one would not expect nor desire to see such standardization of surgical technique. Nevertheless, it is apparent that some methods of hemorrhoidectomy lead to more postopera-

tive pain than do others. The operative procedure which will remove the fundamental pathology with the least amount of trauma logically becomes the operation of choice. With this in mind, I have found the ligature transfixion operation as practiced for years at St. Mark's Hospital in London to fulfill the requirements. I do not believe that any technique which involves the use of the cautery, the wide dissection of perianal tissues, or the placing of multiple sutures, as coming within the category of a choice operation.

It is well worth remembering that even in a choice type of operation, there are certain errors of omission or commission which spell the difference between pain and ease to the convalescing patient, as the following points will indicate:

1. The ligature which is passed around the varicosity should be pulled snugly enough to produce hemostasis, but to pull this ligature with all one's strength will cause more postoperative pain.

2. Chromic catgut, silk, kangaroo tendon, or linen causes more pain than plain No. 0 or No. 1 catgut.

3. The mucous membrane covering the pile must never be stripped high so as to leave a large denuded area. If stripped above the level of the anus, painful contracture will result.

4. The forceps used to grasp the hemorrhoids should be of a type which will not tear the delicate tissues. The Allis forceps fulfil this requirement very well. Only gentle traction need be applied.

5. In placing the ligature around the hemorrhoids, great care should be exercised so as not to include muscle in the bite. If this is done it will cause painful contractions of the sphincter ani during convalescence.

6. External hemorrhoids and redundant skin must not be removed in excess. Fine judgment must be exercised or large gaping wounds will cause no end of pain and burning.

7. The removal of an insufficient amount of redundant skin with correction at a later date is far better than the

removal of an excess at the time of the operation.

8. Remove external hemorrhoids, leaving a triangular wound with the base pointing laterally; this will afford sufficient drainage and smooth healing.

9. Islands of skin should be left between areas removed to avoid painful contraction.

10. Care must be taken not to cut too deep. Muscle excised cannot be replaced. Bleeding points should be controlled by temporary pressure with gauze or forceps.

11. Suturing of the perianal skin causes pain, infection, and reduces drainage.

In completing the operation, it is customary for many surgeons to insert a plug, tube or drain into the anal canal. This procedure is second only to divulsion as a cause of postoperative discomfort. The sphincter will contract down on the foreign body rhythmically in an attempt to expel it from its grasp. Each contraction is more painful than its predecessor. The injection of a tube of vaseline, liquid or solid, or some soothing anesthetic ointment is all that is needed.

A dressing should be applied in the operating room which will fit snugly and not slip as soon as the patient is put to bed. To readjust a dressing within an hour or two after operation is productive of pain.

With the patient back in bed, a systematic postoperative régime should be started. The dressings should not be disturbed for a few hours unless there is good reason for such an action. An electric pad (rubber covered) may be adjusted to the buttocks; aspirin compound may be given in moderate doses every two or three hours. Within five or six hours, the bandages are carefully removed and hot wet packs are applied and kept hot by frequent changes. A wad of cotton soaked in witch hazel placed next to the anus is soothing, antiseptic and astringent.

The patient is kept in bed for the first two days. On the third day the administration of hot sitz-baths, two or three times daily or as often as the patient desires, is begun. The wound is irrigated daily with an asepto syringe and a witch hazel and water solution. No attempt is made to start elimination until the evening of the third postoperative day when a warm olive oil retention enema is given with small catheter and bulb syringe.

Traditionally, the first bowel movement is painful. This is not necessary if a few precautionary methods are taken immediately before and after the bowel movement. A hot sitz-bath after elimination will add to the patient's comfort. The anus should be irrigated after each bowel movement. A dressing of liquid or solid vaseline or some soothing anesthetic ointment should be applied. There is no need to insert the finger into the anus until healing has well begun. After the seventh or eighth day, it is well to pass the gloved finger once or twice a week until healing is completed. The patient can apply vaseline or any soothing ointment daily by means of a finger cot.

A soft low residue diet is recommended for the week immediately following operation.

Hospitalization need not extend over five days in uncomplicated cases.

CONCLUSIONS

Traditional postoperative pain following a hemorrhoidectomy is avoidable and unjustifiable.

Comfortable convalescence can be achieved by: (1) avoiding all unnecessary injury to anal tissue; (2) the application of expert and particular care to this most sensitive region; (3) utilization of a tried and tested preoperative and postoperative routine; (4) selection of an open, non-burning, non-traumatizing type of operation.

Operations involving the use of the cautery, wide dissection of perianal tissues and the placing of multiple sutures lead to more pain than the simple ligature transfixion operation.

The practice of inserting plugs and tubes into the anal canal postoperatively as well as divulsing of the sphincter ranks high in the list of causes for pain.

Oily anesthetics are superfluous and are a poor substitute for cleancut surgery.

The traditional fear of the first bowel movement need no longer be a problem providing a few precautionary measures are taken.

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THE mechanism of injury [in fractures in the region of the hip] was generally a combination of direct and indirect violence from a fall. About 60 per cent were injured in their homes.

SELECTIVE SURGERY IN OPERABLE RECTAL CANCER*

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THE treatment of rectal cancer is an interesting but intricate problem. Extirpation of the rectum has been practiced since Lisfranc reported his successful operation in 1926, but during the past quarter of a century there has been a marked improvement in the surgical treatment of this disease. New types of operative procedures have been described, and the surgical technique of rectal resections has been greatly improved. Despite these improvements, there is not, as yet, any one procedure that is suitable for routine employment in all cases. Two factors, (1) the variation in the extent of disease at the time patients are referred for treatment, and (2) the variation in the ability of patients to withstand radical resection, make selective surgery preferable to the routine use of any one method.

The types of operation that have proven of greatest value and appear worthy of consideration in selecting treatment for operable diseases, are: (1) abdomino-perineal resections completed in one or two stages; and (2) perineal resections with or without preliminary colostomy. Each of the above procedures has a field of usefulness in the surgical treatment of this disease. Most appropriate selection can be made from the knowledge of the comparative advantages and limitations of each procedure, the pathologic factors of the disease presented, and the general physical condition and the psychology of the patient.

Early diagnosis is the greatest asset to successful treatment regardless of the method employed. Rectal cancer begins as a local disease in the mucosa and extends both by direct continuity of the disease and by dissemination through the lymphatic and blood streams. If it were possible, uniformly, to recognize cancer in the early in-cipient stages, treatment would be greatly simplified and excellent results obtained by the majority of the above methods of procedure. Unfortunately, many operable lesions are well established, often with involvment of the lymphatic and the adjacent tissues, at the time patients come under observation. As a rule, the extent of the disease has a marked bearing upon the prognosis, which, however, may be favorably influenced in certain instances, when the disease is no longer localized, by employment of more radical forms of surgery.

The ability of patients to withstand operation should be carefully considered. Certain types of resection are accompanied by greater degrees of shock and more severe complications than others. In most instances in the treatment of cancer in this location, it is advisable to employ the most radical dissection that the patient appears able to withstand, as one is never sure of the extent of the disease. The problem of selecting treatment is a comparatively simple one when dealing with patients in good physical condition. Unfortunately, rectal cancer frequently occurs in patients of mature and old age. Many of these patients are also victims of heart, lung, kidney, metabolic or other chronic diseases, factors which increase the hazards of successful resection. It is impossible to treat rectal cancer adequately without a certain percentage of operable fatalities. The latter, however, may be held at a reasonably low figure by attempting to keep the treatment within the tolerance of the patient and at the same time to afford him the benefit of the most radical resection that he is able to withstand. Operable mortality, in all types of resections, has been lessened by more careful preoperative

preparation, by liberal employment of blood transfusions, better surgery and more detailed after treatment.

By obtaining a careful history and by detailed physical and laboratory investigations, the surgeon may estimate the patient's ability to withstand operation to a rather accurate workable degree. In accordance with these investigations, patients with operable disease may be separated into four groups, (1) good, (2) medium, (3) poor, and (4) bad surgical risks. Although the primary disease may be removable in patients classified as bad risks, the poor physical condition contraindicates the employment of radical surgery.

Location of the tumor may also, at times, influence the selection of surgical treatment. The term, rectal cancer, frequently includes lesions situated anywhere from the anus to the rectosigmoidal junction. Low lesions, within reach of the index finger, may or may not be suitable for perineal extirpation, depending upon the extent of the disease and condition of the patient. The most appropriate approach for tumors in the upper rectum and at the rectosigmoidal junction is by way of the abdomino-perineal route, unless this form of surgery is contraindicated by the patient's poor physical condition.

Abdomino-perineal resection is the ideal surgical method of approach in eradicating rectal and rectosigmoidal cancers. This type of operation permits removal of the primary tumor with a wide dissection of adjacent tissues and lymph-drained areas. The terminal intestinal tract from the middle of the sigmoid to the anus is also removed. The patient retains a permanent colostomy. Abdomino-perineal operations may be completed at one time as advocated by Miles, or the dissection may be in two stages as suggested by Coffey, Rankin, Lahey and others. The choice between the one- and the two-stage procedures rests largely upon the general physical condition of the patient, the degree of obstruction, the degree of infection and the extent of the disease.

The one-stage or Miles' type of procedure has the advantage of being completed at one time. Patients are immediately relieved of the worries and fears of a second operation. Convalescence, if uncomplicated, is short, and the majority of patients leave the hospital within four weeks. The chief objection to the one-stage procedure, when it is routinely employed, is the accompanying high operative mortality. Miles, however, has shown that the mortality from his operation may be kept comparatively low by selecting suitable cases. Experience in the selection of cases and improvement in surgical technique tend to increase the popularity of the one-stage operation.

Two-stage abdomino-perineal resections have been devised to accomplish with a comparatively lower operable mortality a similar dissection to that afforded by the Miles operation. Of the two-stage procedures that have been described, the Lahey technique has received the greatest popularity. This operation appears to offer certain advantages over other two-stage procedures. The main objectionable features of this resection, outside of the inevitable two procedures, are (1) reopening the abdomen at the site of an intestinal stoma, and (2) contending with adhesions which, at times, follow the first procedure. Despite these objectionable features, operable mortality is quite low. Shock is seldom severe, and fatal peritonitis is relatively rare. The technique, as described by Lahey and his staff, has been followed in most of our cases. In a few instances, when dealing with large friable, borderline operable lesions at the rectosigmoidal junction, in order to lessen the likelihood of rupture into the bowel or tumor, we have modified the technique. The second operation is begun in the usual manner. After tying the superior hemorrhoidal artery and loosening the rectum posteriorly, the dissection is then completed from below and the tumor removed by the perineal route. The new pelvic floor is then constructed and the abdominal wound closed in the

usual manner. This technique converts the second stage into the abdominoperineal abdominal type of procedure. Whether this variation in technique is of any value under such circumstances will require additional experience to estimate fully.

Judging from a limited experience of fifty-six abdomino-perineal operations in which there was an operative mortality of 12.5 per cent, we think there is a definite field for both one- and two-stage procedures in the routine treatment of rectal cancer. One-stage operations appear to be best suited for good surgical risks with early or moderately advanced lesions. Two-stage procedures are suitable for medium surgical risks and for that small group of patients classified as good risks with badly infected, stenosing, borderline operable cancers. The percentage of clinical cures following these types of resections should be superior to that of restricted methods of surgery. Such results, however, will depend largely upon the extent of disease in those cases selected for this method of treatment.

When sufficient time has elapsed to compare the ultimate results of the one- and the two-stage abdomino-perineal operations, in all probability such results will vary more in accordance with the extent of disease at time of operation than with the method of procedure employed.

PERINEAL RESECTIONS

Perineal resections are limited operations in that there is less opportunity for dissecting the areas drained by the lymphatics than with the abdominal types of procedures. Limited dissections are capable of producing clinical cures only when all cancer cells can be removed. Perineal resections, therefore, from the standpoint of obtaining clinical cures, are best suited for cancers within the lower half of the rectum in which the disease is well localized. Such favorable conditions are encountered at times when the disease is recognized in the early stages and when

the histologic report reveals a low grade of malignancy.

The extensive routine employment of perineal resection by many surgeons, as a method of eradicating rectal cancer, has been due to the low operative mortality following this type of operation, and to the high operative mortality which accompanied abdomino-perineal resections a decade or more ago. Operative mortality from the perineal operation in our clinic is less than 5 per cent. Because of this low mortality and despite its limited nature, this operation has a real field of usefulness in cases where patients in poor physical condition are quite unlikely to withstand more radical forms of surgery. The final results of perineal resections from most clinics are less gratifying than those following abdomino-perineal resections, although Lockhart-Mummery, in a recent communication, gives figures which compare favorably with the most radical procedures. The low percentage of clinical cures reported may be largely accounted for by the frequent employment of this type of resection in advanced stages of disease. It is often employed with borderline and inoperable disease and with patients in poor physical condition, the objective being palliation rather than clinical cure. Perineal resections are best reserved for that group of patients who, because of old age and chronic constitutional disease, are considered poor surgical risks, and for the small percentage of patients with low-lying tumors which still remain in the early stages of development.

The rectum may be resected by the perineal route, with or without the constuction of a preliminary abdominal colostomy. A preliminary operation permits exploration of the abdomen to determine the presence or absence of metastatic disease, and places the artificial anus in a convenient location for cleanliness and care. Preliminary colostomy often permits a wider dissection of the pelvis and the removal of larger sections of the rectum. The operative mortality is but little

influenced by a preliminary operation. Perineal resections without colostomy may be preferable when dealing with very obese patients and those who absolutely refuse to have an opening on the abdominal surface. Perineal stomas function satisfactorily in the majority of instances, but they are less accessible for irrigations and cleanliness than those situated upon the abdomen.

Operations that attempt continuity of bowel and sphincter control have not proved to be very satisfactory in the treatment of rectal cancer. Procedures such as local excisions, perineal resections with preservation of the anal sphincter, and abdominal resections with anastomoses have been employed in an effort to avoid a permanent artificial anus. We have had but little experience in performing the above types of resection, but have seen many recurrences in patients subjected to these operations from other institutions. The chief objectionable feature to operations devised to avoid colostomy is the high percentage of recurrences. Early recurrences are due to incomplete removal of the cancer. Resections with continuity of bowel and sphincter control have a limited field, and are best reserved for patients who absolutely refuse to be operated upon if they are to retain a permanent colostomy, and for a small percentage of early rectal and sigmoidal cancers that are favorably situated for limited surgical dissections. In many instances of early rectal cancer, eradication of the disease by radiation therapy which leaves the patient with a normal functioning intestinal tract, is preferable to limited surgical resections.

CONCLUSIONS

Selective surgery in operable rectal cancer is advisable because of variations in (1) the location of lesions, (2) the extent of disease, and (3) the physical condition of the patient. Abdomino-perineal resections, completed in one or two stages, afford the widest forms of dissection, and are preferable for the majority of patients who are classified as good and medium surgical risks. Perineal resections, with or without preliminary colostomy, are best suited for tumors situated in the lower two-thirds of the rectum in patients classified as poor surgical risks. Resections which attempt continuity of bowel and sphincter control have but a limited field in present day surgical treatment of rectal cancer.

THE CEREBRAL EPIDERMOIDS (CHOLESTEATOMAS)*

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INTRODUCTION

CHOLESTEATOMAS are a rare type of tumor encountered in various parts of the brain and cranium. Cushing found fourteen tumors of this type among 2,004 verified brain tumors. In the series of Dr. C. H. Frazier, eight cholesteatomas have been encountered at operation over a period of eight years. It can be seen therefore that their incidence is very low. Since these tumors are so strikingly different from other brain tumors in their histologic appearance, and since they are so readily removed surgically, it seems well to inquire further into their clinical features and into their methods of growth. For this reason I record eight cases of cholesteatoma from the collection of Drs. Francis C. Grant and C. H. Frazier. These were found in the following locations: cerebrum (parietal lobe), one; cerebellopontile angle, two; pineal recess, one; fourth ventricle, one; sphenoidal ridge one; suprasellar, one; occipital bone, one. The features of cholesteatomas in these various locations will be considered separately.

CEREBRAL CHOLESTEATOMAS

Cholesteatomas may be found in relation to any part of the cerebral hemisphere. They are not so numerous in the cerebrum as they are at the base of the brain or in the posterior fossa, but they occur with sufficient frequency over the cerebral hemispheres to warrant an analysis of their clinical features. They have been found in the frontal (Love and Kernohan[1]), temporal (Love and Kernohan, Nehrkorn,[2] Kakeshita[3]), parietal (Alpers, Critchley and Ferguson[4]), and occipital regions (Nehrkorn). (Fig. 1.) They are probably more commonly found in relation to the temporal lobes than to other parts of the cerebrum, and may lie within the brain substance or on it. When they lie within it, they represent tumors which have made a bed for themselves by compression from without, the brain enfolding them in this process. Sometimes they lie extradurally, compressing the brain from without. In such cases they may frequently be intradiploic cholesteatomas with extension into the cranial cavity and compression of the brain. Such cases show characteristic roentgenographic pictures due to destruction of the bone in the area of compression by the tumor.

Case 1 illustrates the clinical features of a cholesteatoma found in the left parietal lobe.

Case 1. H. B. was admitted to the University Hospital on August 7, 1928, under the care of Dr. C. H. Frazier. She had had weakness of the right leg for fourteen years. This had remained unchanged until two years before entrance when she suddenly developed jerking of the right leg and foot followed by jerking of the right knee and finally of the abdominal muscles. These convulsive attacks were without loss of consciousness. Following them the weakness of the right leg became definitely greater so that she was unable to use this limb for a few days after an attack.

Examination revealed weakness of the right arm and leg, especially on flexion movements, increased tendon reflexes in the right leg, and a questionable Babinski sign. The rest of the neurologic examination was entirely negative. Ophthalmalogic examination revealed no papilledema.

An encephalogram, performed because of the few localizing signs, pointed to a lesion in the left frontal area. A large left frontoparietal

craniotomy was performed by Dr. C. H. Frazier on October 25, 1928. A large tumor was found at the upper end of the left precentral and postcentral areas close to the longi-

SUPRASELLAR CHOLESTEATOMAS

Sometimes intracranial cholesteatomas are found in the suprasellar region (Olive-

Cholesteatoma, parietal lobe

Cholesteatoma, vent. IV
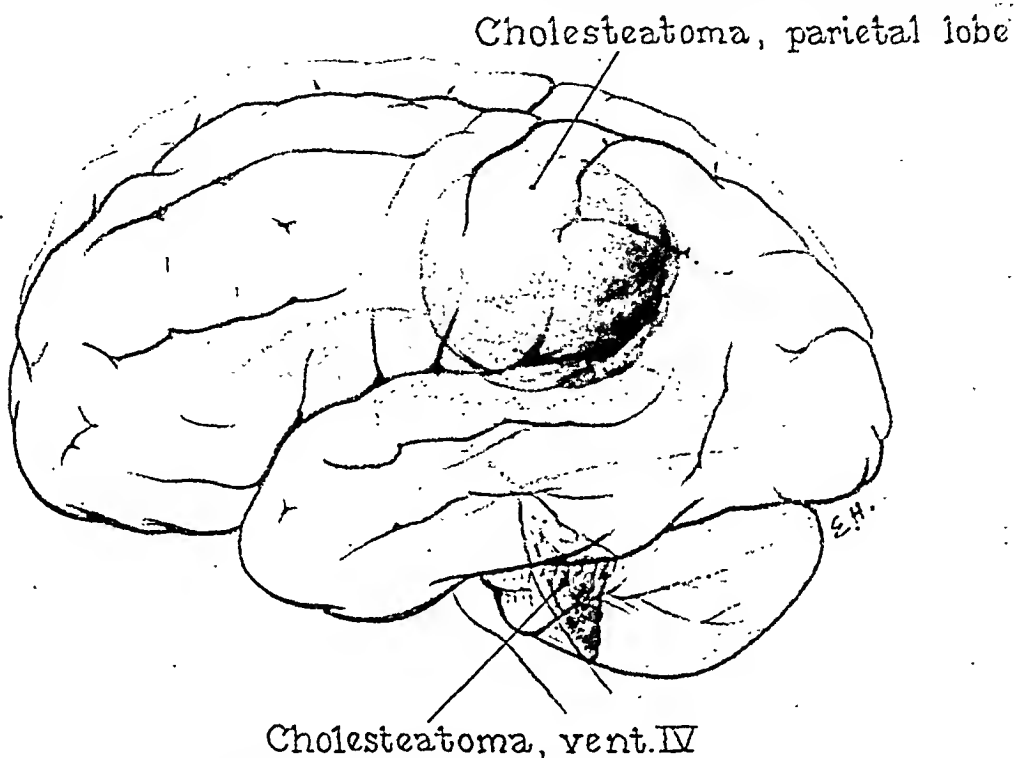
FIG. 1. Cerebral cholesteatoma of the parietal lobe. Note also the fourth ventricle cholesteatoma.

tudinal sinus. When this tumor was removed the cavity measured 10 cm. in length and extended down to the lateral ventricle. Grossly the tumor had the appearance of a cholesteatoma. Histologic study revealed a typical cholesteatoma with a characteristic capsule in which no keratohyaline was seen.

The patient made a good recovery and when last heard from in 1929 was well.

There is nothing in the clinical features of these tumors to differentiate them from other slowly growing brain tumors. They run a slow, progressive course, which, in the case recorded above, was of fourteen years' duration. It is only when cranial defects are seen in the roentgenogram that one is able to make a preoperative diagnosis clinically.

In Case 1 a good recovery followed the operation. Similar recoveries have been recorded by Learmonth and Kernohan[5] in a frontal lobe cholesteatoma.

crona,[6] Love and Kernohan). Olivecrona believes that such tumors can be diagnosed before operation on the basis of the following clinical characteristics: (1) the development of a very slowly progressive primary optic atrophy with bitemporal hemianopsia occurring in a young person; (2) the presence of an essentially normal sella turcica with widening of the optic foramina, and pressure absorption of one or both anterior clinoids and of the sulcus chiasmatis; and (3) the complete absence of signs of pituitary insufficiency. Since most of these signs are found with other tumors in this region, the establishment of such a syndrome for cholesteatomas is difficult to accept. Olivecrona believes, however, that the occurrence of these tumors in young people differentiates them from the suprasellar meningiomas, that their growth is slower than is the case with the latter or any other tumor in this

region except the hypophyseal duct tumors, that widening of the optic foramina occurs most frequently with these tumors, and that bone absorption is more characteristic of the cholesteatomas than of other tumors in the suprasellar region. Despite these apparently characteristic features, suprasellar cholesteatomas cannot be diagnosed except at operation. Their features are the features of suprasellar tumors with a chiasmal syndrome which apparently has no specific characteristics. This is illustrated by Case II. (Fig. 2.)

CASE II.   M. S. was admitted to the University Hospital under the care of Dr. C. H. Frazier on December 8, 1931. She had been well until two years previously when she began to be troubled with headaches which became less frequent and less severe as time wore on. At the same time her eyesight began to fail. This had become steadily worse so that at the time of entrance she had great difficulty in seeing with the right eye and could hardly distinguish light with the left.

Examination revealed bilateral primary optic atrophy. The left visual field could not be taken because of the blindness. The right showed a temporal cut, with some encroachment on the inferior nasal quadrant as well. Otherwise the examination was negative. There were no signs of endocrine imbalance, but there was a history of irregular menses. The basal metabolic rate was minus 16 per cent.

X-ray of the skull revealed a very long and shallow floor of the sella turcica. The sella measured 9 × 7 mm. and its appearance suggested a suprasellar tumor.

On December 17, 1931, Dr. Frazier performed a right transfrontal craniotomy. A "pearly tumor" was found above the sella turcica, more on the right side. This was removed almost completely.

Histologic study revealed a typical cholesteatoma. The capsule was well-defined. The epithelial layer was several layers thick with a bottom layer of cuboidal cells sitting on a heavy basement membrane. Above these lay three to four layers of cells having no definite arrangement but lying at right angles to the basement layer. The cytoplasm of these cells merged with that of those adjacent and was poorly defined. Keratohyalin granules could be made out in

the basement layer of cells. In addition there was a clearly defined stratum fibrosum composed of parallel layers of fibrous tissue. The
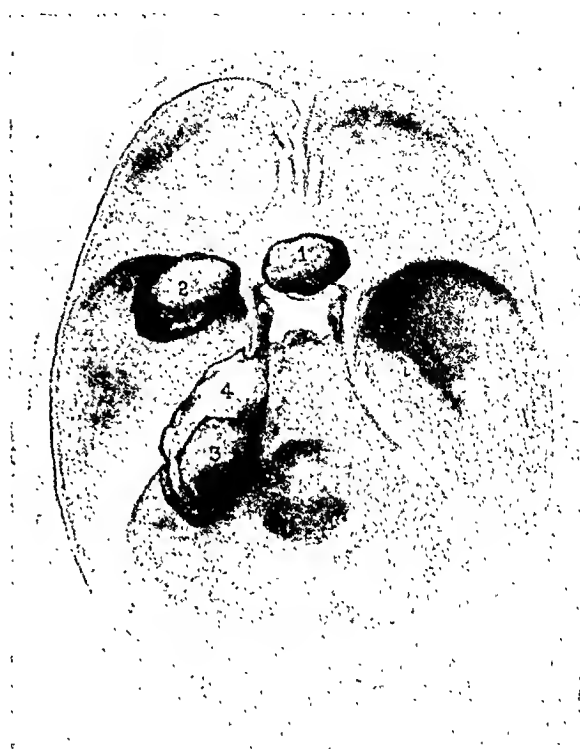
FIG. 2. A composite picture to show the position of the cholesteatomas at the base of the brain in this series. 1, suprasellar (Case II). 2, sphenoid ridge or parasellar (Case III). 3, cerebellopontine angle (Case IV). 4, parapontine (Case V).

stratum cellulosum with its large polyhedral cells was seen plainly.

The patient made a good operative recovery. The vision in the left eye never returned, but the right visual field widened out and the vision increased to 3/100. She did well until 1935 when she developed recurring blindness in the right eye and improved vision in the left. Operation was advised, but was refused.

This case occurred in a young girl of fourteen and in this respect conformed to the experience of Olivecrona. In all other respects, however, only the signs of a chiasmal syndrome enabled the establishment of a diagnosis of suprasellar tumor.

Suprasellar cholesteatomas are usually small tumors confined to the suprasellar region, but they may become very large and extend into the adjacent middle fossa (Love and Kernohan). Their relation to the optic chiasm does not differ from

other types of suprasellar tumor. They lie under the chiasm, pushing it up, the optic nerves straddling the tumor. While Olivecrona states that bone absorption and dilatation of the optic foramen is seen in these tumors, I am unable to confirm this, either in the single case reported in this series or in the experience of others.

PARASELLAR CHOLESTEATOMAS

One of the more usual situations of cholesteatomas within the skull is in the parasellar area either on the lesser or greater sphenoidal wings. (Fig. 2.) These might be regarded essentially as cholesteatomas of the middle fossa which happen to be located on the sphenoid ridge. Indeed it is not unusual for them to extend into the middle fossa from the ridge just as do other tumors in the same area. The following case illustrates some of the features of a cholesteatoma of the sphenoid ridge:

CASE III.   S. L. entered the University Hospital on June 18, 1931, under the care of Dr. C. H. Frazier. She had been subject to headaches for the past eighteen years, but these were very rare, coming not more often than once a year. However, they lasted for one to six weeks, and were often associated with nausea and vomiting. About six months before entrance she had a severe headache over the left forehead, eye, and temple. This lasted for three months. Just before its onset she noticed her vision was failing and that it was worse in the left eye. Following the removal of several teeth she became completely blind in the left eye, and developed drooping of the left eyelid. After three months, the headache vanished until five weeks before entrance, although the ptosis persisted. The headache lasted until the time of entrance.

About one year before entrance she had what seemed to be typical uncinate attacks during which she smelled old burning rags. She had hallucinatory experiences in her left visual field, during which she saw figures of people and stones of different colors.

Examination at this time revealed Argyll-Robertson pupils, bilateral primary optic atrophy, a left external rectus weakness, a left trochlear paralysis, ptosis of the left eyelid, and pain in the first division of the left trigeminal nerve. The left visual field was contracted, but there seemed to be a much more pronounced cut in the temporal portion of the field. The blood Wassermann was negative. X-ray of the skull and sella was negative.

The patient insisted on leaving the hospital before a final diagnosis was made. She returned in April 1935 with the story that for four years she had been well except for mild headaches. The vision in her right eye was good enough to read with, but the left eye was blind. Since there was a severe recurrence of her headache before entrance she returned for observation. Examination at this time revealed a moderate exophthalmos in the left eye, ptosis of the left eyelid, a left external rectus palsy, and a blurring and papillitis of both optic nerve heads. X-ray of the skull at this time showed a well-circumscribed mass just posterior and to the left of the sella turcica. This mass had a calcified periphery.

On March 26, 1935, Dr. C. H. Frazier performed a left temporofrontal craniotomy. A tumor was found on the lesser wing of the left sphenoid bone, extending back into the middle fossa. It was attached to the ridge. A large part of the tumor was removed.

After operation the patient did quite well, but she had a rapid recurrence of symptoms and died in May 1935. No autopsy was obtained.

Histologic study of the tumor showed it to be a cholesteatoma. No capsule was found in the many fragments of tissue removed. However, the large polyhedral cells of a cholesteatoma were seen everywhere in the tissue and this, plus the gross appearance, made a diagnosis of cholesteatoma quite justified.

The trochlear, abducens, and trigeminal paralysis on first examination indicated a parasellar lesion. This was confirmed on second admission by the development of partial left oculomotor paralysis, and exophthalmos of the left eye. The visual fields were of no help because of the loss of vision in one eye, but the uncinate fits were of great value in indicating a lesion adjacent to the uncus region. None of these signs were in any way different from those found in other tumors of this region. The calcification of the

tumor had no features which could be regarded as in any way specific.

That the parasellar area is one of the more common sites of location of the cholesteatomas is shown by the fact that in 142 such tumors collected from the literature by Mahoney,[7] forty-four were in the parasellar or parapituitary region. Mahoney's parapituitary cases include probably not only the parasellar but also the suprasellar cases. He found no evidence of a characteristic syndrome for cholesteatomas in this region.

PARAPONTINE CHOLESTEATOMAS

Among the parapontine cholesteatomas may be included tumors of this type which lie in the cerebellopontine angle as well as those which lie in juxtaposition to the pons outside of the angle. (Fig. 2.) Since there are not a few tumors which lie in relation to the pons outside of the angle, it is probably wiser to accept the term parapontine (Mahoney) than to include them all among the cerebellopontine tumors. The cerebellopontine angle is one of the favorite sites of the cholesteatomas. One of the eight cases which I record was found in this location (Case iv), and another along the pons (Case v).

Case iv. R. D. entered the University Hospital under the care of Dr. C. H. Frazier on August 26, 1932. She had had difficulties in hearing with the left ear since 1925, about seven years before entrance, which became gradually worse until she could no longer hear with this ear. About the same time she developed tinnitus in the left ear, and then bilaterally. It was worse in the right ear and had become quite constant. For four years she had been troubled with dizziness especially on rising in the morning, induced by any change of position. About three years before entrance she noticed inability to coordinate the left arm and leg and found that these limbs were weak. Thickness of speech, severe occipital headaches, and dimness of vision completed the clinical picture.

Examination revealed a spontaneous horizontal, vertical, and rotary nystagmus, a diminished left corneal reflex, early evidences of a left peripheral facial palsy, dysmetria and dyssynergia of the left arm, a reeling gait with falling to the left, unsteady station, and left-sided loss of cochlear function. There was 1D papilledema in each eye. The Barany findings were typical of a cerebellopontine angle lesion. X-ray of the skull revealed nothing of interest.

A suboccipital craniectomy was performed on August 27, 1932 by Dr. F. C. Grant. A cholesteatoma was found in the left cerebellopontile angle and was removed in toto except for a small piece of capsule which was attached to the trigeminal nerve.

Histologic study revealed a typical cholesteatoma. There was a typical capsule, composed of a basal layer of cells with large vesicular nuclei and a roomy cytoplasm containing basophilic staining granules of varying sizes. There were two or three layers of cells about the basal layer. Their structure was similar to those of the basilar layer, but they tended to become flatter as one approached the surface. There was a well-defined stratum fibrosum and granulosum.

The next case is most unusual because of its great extent. (Fig. 2.) This tumor covered the left side of the brain stem, compressing both the pons and medulla extending through the incisura beneath the left temporal lobe. Despite its size, it produced relatively few signs.

Case v. K. M. entered the University Hospital March 30, 1936, under the care of Dr. C. H. Frazier. About three years previously she had developed a left Bell's palsy which apparently persisted. Two years later she noticed staggering which had become progressively worse, and for three months she had been troubled with diplopia. She had never had headaches or vomiting.

Examination revealed a left oculomotor weakness, an absent left corneal reflex, deviation of the jaw to the left, weakness of the left abducens nerve, a peripheral left facial paralysis, deafness in the left ear, immobility of the pharynx, weakness of the right hand and hyperactive reflexes. Visual field studies revealed enlargement of the blind spots. Barany studies revealed a brain stem lesion on the left side, probably in the angle. Vestibular and cochlear responses were absent on the left side.

On April 2, 1936, Dr. S. N. Rowe performed a suboccipital craniectomy. In the left cere-

bellopontine angle was a large tumor which extended from the upper end of the spinal cord along the brain stem beyond the tentorium,

FIG. 3. Cholesteatoma in fourth ventricle. The medulla has been pinned back in order to show the tumor. (Case VI.)

disappearing beneath the left temporal lobe. All the tumor in the posterior fossa and part of that portion in the middle fossa were removed. She made a good recovery but there was no improvement in her facial paralysis.

Histologic study revealed a cholesteatoma. There was no capsule, but there were many polyhedral cells, and this, with the typical gross appearance of a pearly tumor, identified the growth as a cholesteatoma.

Cholesteatomas in the parapontine region are more numerous than in any other part of the brain or brain stem. Of the 142 cases collected by Mahoney, fifty-three were in the parapontine region compressing the pons either anteriorly or in the cerebellopontine angle. There is nothing to differentiate these neoplasms clinically from other tumors in the angle. They give a history of a typical cerebellopontine angle tumor.

FOURTH VENTRICLE CHOLESTEATOMAS

In a small number of instances cholesteatomas are found within the fourth ventricle. Mahoney found fifteen such instances among 142 cholesteatomas. The

following case (Fig. 3) illustrates the features of a cholesteatoma in this location:

CASE VI. M. H. was admitted to the University Hospital August 1, 1932, under the care of Dr. C. H. Frazier. She had been well until five months before entrance when she fell down the stairs. Following this she noticed weakness of the right leg. For several months before her fall, however, she had observed that she was unable to use her right hand and arm well; she had great trouble in writing, in threading a needle, and in knitting. Delicate movements involving the right hand were difficult to perform. For about five months there had been weakness of the right arm. One month before entrance her gait became unsteady so that she had to hold on to the furniture for support. She noticed a tendency to fall to the right in walking. Diplopia developed a month before entrance into hospital.

Examination revealed horizontal and vertical nystagmus, dyssynergia of all the limbs, more marked on the right side, a staggering gait with reeling toward the right side, slight drooping of the lower part of the right face, and bilaterally hyperactive reflexes. There was 1.5D of choking in each eye.

X-ray of the head revealed severe atrophy of the dorsum sellae with retention of the posterior clinoids, increase in size of the sella turcica (11 × 9 mm.), and erosion of the sellar floor on the right side.

A suboccipital craniotomy was performed on August 12, 1932, by Dr. Francis C. Grant, and a fourth ventricle cholesteatoma was revealed. The patient collapsed on the table before any efforts could be made to remove the tumor.

Histologic study revealed a typical cholesteatoma with a capsule composed of several layers of epithelial cells, the basement layer composed of large cuboidal cells containing many basophilic granules in the cytoplasm. The stratum fibrosum and cellulosum were easily made out.

The diagnosis of a fourth ventricle tumor is exceedingly difficult. Frequently the signs are obscure and are those only of increased intracranial pressure. Sometimes, as in Case VI, the signs are predominantly cerebellar in type, a fourth ventricle tumor being disclosed only after a posterior fossa exploration. Here there

were no signs which could be regarded as specifically indicating a cholesteatoma. The clinical signs pointed to a cerebellar

Examination revealed a combination of mental and cerebellar signs. The pupils reacted sluggishly to light. Dyssynergia was present in
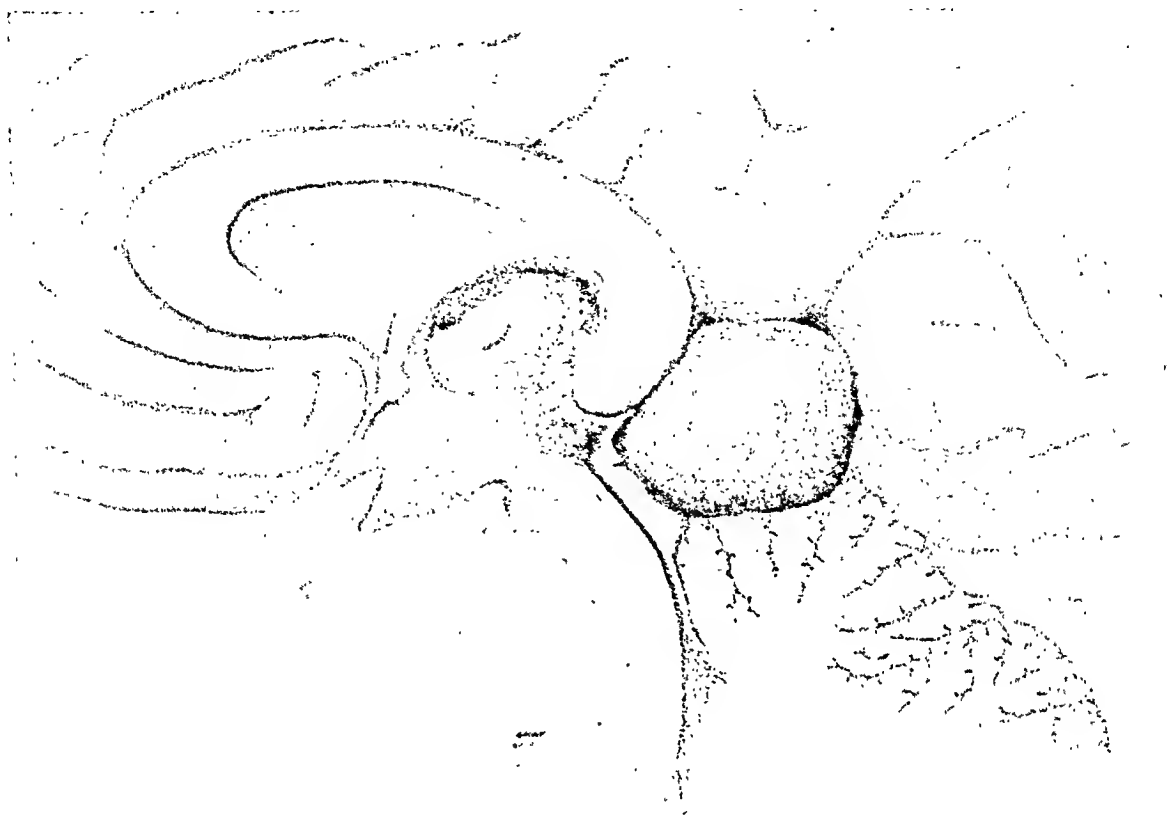
Fig. 4. A large cholesteatoma in the pineal recess. (Case vii.)

tumor; that it was a fourth ventricle cholesteatoma was disclosed only after exploration.

CHOLESTEATOMA OF THE PINEAL RECESS

Cholesteatomas in this region are very uncommon. None are mentioned among the 142 cases culled from the literature by Mahoney. The following Case (Fig. 4) illustrates the features of a tumor in this region:

CASE vii. E. M. was admitted to the University Hospital September 5, 1934, under Dr. C. H. Frazier. About two years before entrance he began to have difficulty in walking, noticing a tendency to stagger to the right. He had had headaches for the same length of time, and vision had been failing for about a year. His difficulty in walking became progressively worse and finally necessitated hospitalization.

the right arm. There was an intention tremor of the right hand, the gait was very unsteady and on a wide base. The memory for recent events was poor and the patient was very facetious.

The fundi showed 1.5–2 diopters choking on the right and 1 diopter on the left. There was post-papillitic optic atrophy. Vision was lost on the right and was $6/60$ on the left.

The x-ray showed evidences of increased intracranial pressure due to posterior fossa tumor. Convolutional atrophy, enlargement of the sella turcica with loss of the dorsum sellae, and some depression of the sellar floor were present. The pineal body was displaced posteriorly.

Ventriculogram was performed on September 13, 1934, because of the difficulty in localizing the process clinically. Air studies revealed dilatation of the lateral and third ventricles but no air was seen in the iter or fourth ventricle. It was decided that there was a block in the region of the third ventricle, possibly due to a pinealoma.

Operation. On September 13, Dr. R. A. Groff performed a subtemporal decompression in order to give some relief from pressure symptoms and to permit an approach to the pineal recess.

On August 20, Dr. S. N. Rowe performed a second operation. A right temporofrontal approach was made. Under the corpus callosum, in the pineal recess was found a tumor which had the typical appearance of a cholesteatoma. The tumor measured about 5 cm. in all diameters. The patient lingered on for a few weeks after operation, but finally died.

Histologic study of the tumor revealed a cholesteatoma. There was a well-defined epithelial capsule composed of three or four layers of cells. Their structure was similar to those of the preceding case. All the other layers of a cholesteatoma were present. There was a heavier fibrous layer than in some of the other tumors, and large number of lymphocytes.

Here too there was nothing to permit a preoperative diagnosis of cholesteatoma. The signs present in this case were obscure at best and did not indicate a process localized in the region of the pineal body. Only after air studies was the location of the tumor revealed.

CHOLESTEATOMA OF THE SKULL

Occasionally cholesteatomas arise within the bones of the skull between the inner and outer tables. Mahoney has gathered twenty-three such cases from the literature. The following example of this type has been reported previously (Alpers and Harrow[8]).

CASE VIII. This woman of 52 had a cholesteatoma of the right occipital bone. She had had symptoms for twelve years, chiefly visual disturbances, headache, and nausea. She was operated on and a large cholesteatoma removed from the right occipital bone. It had produced a severe bulging of the inner table, some erosion of this table, and compression of the brain. It was entirely extradural and was removed completely. She made an excellent recovery.

The subject of the diploic cholesteatomas has been reviewed on several occasions, especially by Cushing,[9] Alpers and Harrow, and Bucy.[10] Cholesteatomas arising within the skull bones have been found in the frontal, temporal, occipital, parieto-temporal, and temporo-occipital regions. They grow very slowly, and remain extradural throughout their course. They usually cause an expansion of the inner table of the skull and a compression of the underlying brain substance, but they may cause an erosion of the outer table and infiltrate the tissues beneath the scalp. This is an uncommon feature, but it has been found in a few instances.

Diploic cholesteatomas give rise to very few signs until they compress the brain substance, and then the signs are only of the vaguest sort. The one certain way of diagnosing these tumors is by *x*-ray, which shows a separation of the tables of the skull, thinned by the pressure of the expanding tumor. The inner table usually suffers more than the outer. Sometimes one finds erosion of this table. Usually there is bone absorption and destruction in the region of the tumor, sometimes of a severe degree. The Roentgen picture, as Cushing has said, resembles very much an old craniotomy defect.

DISCUSSION

Incidence. Cholesteatomas are relatively rare brain tumors. They represent 0.6 per cent of verified brain tumors in Cushing's series. In Frazier's series of 758 verified cases, there were eight cholesteatomas representing 0.13 per cent. They may occur at any age. The ages in the eight cases reported in this paper varied from 14 to 58. The average age in the 142 cases gathered by Mahoney was 35, the extremes being from $1\frac{1}{2}$ to 78. There is no preponderance in either sex.

Pathology. The story of the cholesteatomas has been told many times. Good accounts of their pathologic characteristics have been given by Critchley and Ferguson, Mahoney, and Bailey.[11] As may be seen from the cases reported and from those gathered from the literature, cholesteatomas may be found in relation to

any part of the cerebral hemispheres, the suprasellar region, the sphenoid bone and middle fossa of the skull in the parasellar to parapituitary area, the pons (parapontine), the fourth ventricle, the bones of the skull, and rarely within the spinal canal. They are most frequently encountered in the parapontine region either in the cerebellopontine angle, where they seem to like to dwell, or in relation to the more anterior portions of the pons. Their next most frequent site is in the parasellar region in relation to the lesser wing of the sphenoid bones or the structures lying close to the sella turcica. The diploic and fourth ventricle cholesteatomas follow them in frequency.

The cholesteatomas are well-defined growths which are discretely separated from the adjacent brain tissue. They practically always lie outside of the brain substance. In the few instances in which they have been described as lying within the brain tissue, the cerebrum and pons, it has seemed definitely true that they had burrowed their way into the brain from without.

The cholesteatomas in the suprasellar area are confined pretty largely to this area. Those which lie on the sphenoid ridge tend to grow into the middle fossa and to burrow under the temporal lobe, whereas the parapontine tumors may sometimes spread far beyond the confines of the cerebellopontine angle and extend anteriorly along the brain stem (Alpers, Mahoney).

Great emphasis has been placed by some (Bailey), on the intimate relation of these tumors to the meninges. In none of my cases was there an adherence of the tumors to the arachnoid, pia, or dura. The tumors have a good capsule. Their glistening, pearly-white, mother of pearl appearance has been too often described to bear repetition. Beneath the capsule are concentric layers of this glistening tissue, giving the appearance of an onion-like arrangement, and the concentric layers may be separated, carefully, in onion-like

fashion. The tissue is very friable and brittle, easily broken even with the most delicate handling.

The microscopic structure of the cholesteatomas is quite constant. The division by Bailey into the following four layers from without inward is in my experience quite satisfactory: stratum durum, granulosum, fibrosum, and cellulosum. The stratum durum is a fibrous layer which frequently contains hematogenous elements, probably from secondary or symptomatic inflammation. It is quite homogeneous in appearance. The stratum fibrosum is composed of many layers of homogeneous material. The stratum cellulosum consists of masses of polyhedral cells of the typical cholesteatomatous variety. The stratum granulosum is composed of epithelium of a modified squamous nature. It has a basilar layer of cuboidal cells in which one can frequently identify keratohyaline granules. Above this are several layers of cells composed of squamouslike epithelium in which one can sometimes identify intercellular bridges.

It is said that the diagnosis of a cholesteatoma depends upon the identification of this epithelial portion of the capsule. Although this is true in general, I have seen cholesteatomas which at operation had the typical appearance of such tumors grossly, but which were removed in pieces and in which a careful search of all the fragments failed to reveal the capsule. All the other elements of the cholesteatoma were present and in such instances I have felt justified in making a diagnosis of a cholesteatoma even in the absence of a capsule. It seems inconceivable to me that a degenerated hypophyseal stalk tumor, a gliomatous cyst, or a brain abscess which has undergone degeneration can become so completely metamorphosed as to give the typical gross appearance of a cholesteatoma. Where cholesteatomas are removed piecemeal, it is quite possible that the capsule may become disintegrated in the process of fixation and dehydration. For this reason I believe that the rule that the

capsule must be found for proper identification of these tumors cannot be too rigidly enforced.

Clinical Features. I know of no way in which a cholesteatoma may be diagnosed preoperatively. There is no characteristic clinical picture in any of the locations in which these tumors are prone to appear. Olivecrona has mentioned certain features which seem to characterize the suprasellar cholesteatomas, but these are not definite enough to distinguish them from other tumors in the suprasellar region.

Mahoney calls attention to the frequent occurrence of mental symptoms in cholesteatomas of the parapontine group, but this can hardly be regarded as a feature of diagnostic value. A similar claim has been made in the case of the cerebral lipomas, often characterized by the presence of mental symptoms. These in themselves can have little value in the diagnosis of a cholesteatoma, though they may direct suspicion toward such a lesion. That the mental changes may be of more than passing interest, however, is shown by the experience of Love and Kernohan, who found a large number of cholesteatomas accompanied by such symptoms. They stated that, "a congenital intracranial dermoid or epidermoid should be suspected in any case in which mental disturbance is associated with headache that has been present for a long time and suggests increased intracranial pressure."

The duration of symptoms in my cases varied from five months to eighteen years. In two cases symptoms had been present for fourteen and eighteen years, respectively (weakness of the right leg in the first instance and headache in the second). The shortest duration of symptoms was found in the fourth ventricle cholesteatoma, as one might expect. A tumor in this region could not exist for long without producing symptoms of some sort.

Treatment. Surgical removal of these tumors offers the only sure method of relief of symptoms. In the eight cases reported in this paper, six made good recoveries, although in one recurrence occurred after a period of five years. Of the 142 cases which Mahoney collected from the literature, 70 per cent died without operation. Of the remaining 30 per cent only one-third survived the operation. Mahoney calls attention, however, to six cases with good recovery reported by Cushing and the recent report of Love and Kernohan in which twelve of fifteen cases recovered, indicating that with more modern methods of brain surgery the possibilities of cure in these cases is good.

If the tumor is removed completely, with the capsule intact, there should be no recurrence. Cholesteatomas are often so situated that they are subject to complete removal. Even in those situated at the base of the brain, it is often possible to remove the tumor in large part, if not completely. Recurrence takes place whenever the capsule is not completely removed, but if the tumor cannot be removed completely, it should be taken out piecemeal. This can be done quite readily since these tumors are soft and easily curetted. While the operative score in the past in these tumors has been none too good, it is probable that with our present improved techniques it will be much better.

SUMMARY

Cholesteatomas may occur in any part of the cranial vault and in relation to any part of the brain. They have been found in relation to the frontal, temporal, parietal, and occipital lobes and in one instance reported here a large parietal cholesteatoma was operated on. They lie outside the brain substance, grow slowly, and may excavate a large area of brain tissue in making a bed for the tumor. At the base of the brain they are found in the suprasellar region, next to the pons (parapontile), in the cerebellopontile angle, and in the fourth ventricle. In none of the areas are these tumors characterized by a typical history or by characteristic findings which enable one to make a preoperative

diagnosis. They do, however, give the signs of a tumor in the areas affected. They may be diagnosed therefore only at operation. Only the skull cholesteatomas may be diagnosed before operation, since they have a characteristic roentgenographic picture. Operation of these cases offers good hope of cure provided the tumor and all its capsule can be removed intact. If the capsule is not removed recurrence is certain.

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TRAUMATIC INJURIES TO THE HEAD

A STUDY OF 200 CONSECUTIVE CASES

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THE problem of traumatic injuries to the head necessarily includes injuries to the scalp, skull, and the brain with its membranes and blood vessels. These injuries are produced in various ways, but violence is the outstanding feature.

Table I presents our series of 200 head injuries from an etiologic aspect and at the same time indicates the degree of associated violence. This clinical material was taken from the Boice-Willis Clinic. The cases were treated by members of the staff, surgical and medical, until a few years ago when the problem was turned over to one person.

TABLE I
ETIOLOGY

Cause	No. of Cases	Deaths
Auto	129	20
Manual violence	23	2
Mule kick	6	1
Falls	8	1
Falls from mule or horse	3	
Motorcycle	2	1
Industrial accident	3	
Bicycle hitting head	2	
Water tank explosion	1	1
Accidental rifle shot	1	1
Thrown as mule ran away	1	1
Baseball	2	
Wagon tongue hitting head	1	
Hitting head on shelf	1	
No history	17	4
Total	200	32

Scalp and skull injuries unassociated with intracranial involvement are to be considered chiefly from the standpoint of prevention of subsequent invasion of infection into the cranial cavity. The danger of the simple scalp wound lies in its apparent insignificance.[1] Every injury to the head should be thought of as being serious until it can be proved otherwise. A careful history should always be taken, including the manner of the injury and the state of consciousness following the accident. The repair of the wound should also include an investigation of the underlying structures for foreign bodies and for damage to the periosteum and skull. In the absence of skull or intracranial disturbance, the potentially infected wound should be converted into a surgical wound

TABLE II

Skull fractures	102
Suspected skull fractures	30
Proved by x-ray, operation, or aural bleeding	72
Of these 72, there were:	
Without cerebral damage	11
With cerebral hemorrhage	20
With gross brain damage	14
Basal	23
Vault	48
Frontal sinus	8
Suture line upset	10
Compound skull fractures	36
(13 died, 9 sequelae)	
Basal	16
Vault	18
Sinus	5
Depressed	22
(5 died, 3 sequelae)	
Compound	13
Operated	13
Parietal	21
(5 died, 9 sequelae)	
Temporal	9
(3 died, 1 sequelae)	
Occipital	6
(No deaths or sequelae)	
Frontal	26
(6 died, 10 sequelae)	

by careful cleaning and débridement, and closed with or without drainage, depending upon its extensiveness. In the preparation of scalp wounds for repair one does well

to remember that the patient, in spite of her beauty, can grow hair with greater facility than she can combat infection.

Compound depressed fractures of the skull are frequently associated with injuries to the membranes, brain, or both.
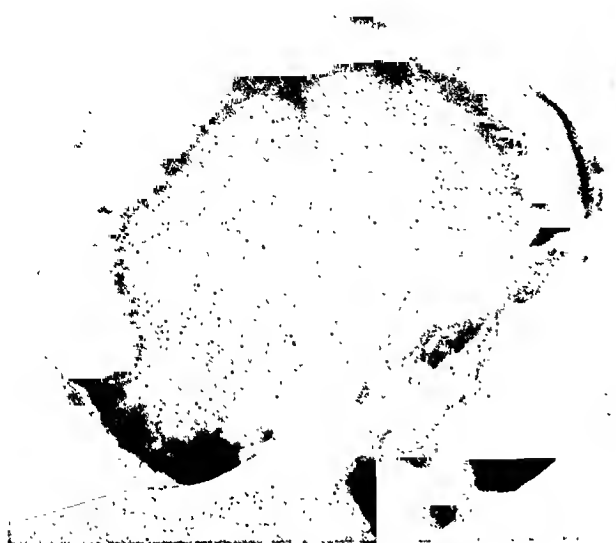
Fig. 1. Compound depressed fracture of skull. Termination in this case was death.

Fig. 2. Compound depressed fracture of skull with extensive bone and brain destruction of the frontal area. This patient recovered without sequela.

Five of the 200 patients here surveyed were admitted to the hospital for scalp wounds.

Simple linear fractures of the vault unassociated with scalp and intracranial injuries are probably no more dangerous than fractures of other bones. The occurrence of uncomplicated linear fractures is shown in Table III. Linear fractures of

TABLE III

Linear fractures...................... 13
   (No deaths, 8 sequelae, 61.5 per cent)
   Intracranial damage.............. 12
   Sequelae...................... 7

the temporal bone have as their principal danger, provided that they do not extend into the base, the possibility of a rupture of the middle meningeal artery or some of its branches.

Simple depressed fractures, not of the massive type sufficient to produce compression per se, are of importance depending upon their locality; i.e., a depressed fracture over a silent area of the cortex may be insignificant, while a depressed fracture over the motor area may present an entirely different picture.

The question of hemorrhage, actual brain destruction, and infection add to the gravity of these injuries, as does their location. Basal fractures are usually compound and are dangerous because they present open avenues to intracranial infection through the ears, nose, mouth and sinuses, in addition to blood vessel damage with resulting hemorrhage. Table IV indicates that hemorrhage and brain damage, and not infection, have been responsible for the deaths in this series. While these

TABLE IV

Basal skull fractures............... 41
   Suspected...................... 18
   Proved........................ 23
Fate of the 41 basal skull fractures:
   Died.......................... 24
     (58.5 per cent—corrected mortality of 44.1 per cent)
   Gross brain damage............. 6
   Cerebral hemorrhage............ 17
   Compound..................... 16
     Sequelae...................... 7
     Slightly deafened.............. 3
     No meningitis
     No rhinorrhea

statistics show that there is a definite relationship between skull fracture and severe brain damage, it must be borne

in mind that "a fatal termination may ensue in consequence of cerebral damage, in the absence of bone injury, or wound of scalp."[2]

Extradural hemorrhage, "the thief in the night of traumatic head injuries," does not offer a great deal of difficulty from a diagnostic standpoint when the symptoms are typical. Verbrugghen[3] reports that in about 10 per cent of the cases coming to autopsy, extradural hemorrhage is regarded as the principal cause of death. In some cases there is no "lucid interval." The unilateral dilatation of the pupil occurs after a primary contraction of the pupil when it is due to extradural hemorrhage; when the patient is seen late, both pupils may be equally dilated. Unilateral dilatation of the pupil, present from the moment of injury, is caused by a damage to the third nerve. Progressive coma and descending contralateral convulsions, spasticity and paralysis, are thought to be the most reliable diagnostic signs of this condition.

That the occurrence of this injury is not dependent upon the presence of a skull fracture or a torn dura, was demonstrated by the author in the performance of a medicolegal autopsy.

Middle meningeal hemorrhage, depressed fractures, compound or not, subdural

TABLE V

	Cases
Surgical treatment of head injuries...	19
Raised bone.	9
Active hemorrhage checked.....	1
Subdural clots removed.........	2
Brain irrigations...............	3
Removal of depressed bone...	5
Irrigation* of brain............	1
Debridement of brain............	1
Craniotomy	
To control hemorrhage.........	1
Exploration for abscess.	1
Removal of blood clot..........	1

* The treatment referred to as irrigations was in reality débridement inasmuch as macerated brain was washed and sucked away.

hematoma, and scalp lacerations require surgical treatment. Table v gives the number of cases operated upon and the type of operation performed. The impor-

tance of the correct management of scalp lacerations per se is well recognized, but will be omitted here in order to give more consideration to craniocerebral injuries.

Shock is generally present to some degree in craniocerebral injuries and demands immediate intelligent attention lest the patient die before the injury can be treated. Heat is the most effective single method.[4] In combating low blood volume in shocked head cases, it is to be remembered that there will be edema of the brain, following the shock. Hypertonic glucose, or preferably sucrose, 50 c.c. of a 50 per cent solution, will replace the volume. Acacia and blood should be used if necessary. Stimulants are best omitted unless hemorrhage can be excluded. "Recovery from shock without hemorrhage is usually prompt unless the injury is so severe that death occurs in a short time."[4] Extracranial hemorrhage must be checked while the shock is being treated.

Compound fractures of the skull, with or without depression, where there are spicules of bone, dirt, etc., require operation as soon as the shock has been combated. Débridement is the best procedure. Where possible, skull fragments are replaced. (Fig. 2.)

Elmer and Boyland[5] state that "rapid immediate decompression with adequate supportive treatment is the procedure of choice in children with depressed fractures." This has been our experience also.

One of the patients included in this series was operated on for subdural hematoma. The operation was performed two weeks after his injury when he was admitted into the hospital in a state of rapidly progressive coma. The operation consisted of saline irrigations through trephine openings. Bilateral exploration of the dura was performed. (Fig. 4.)

None of the cases in this series received a subtemporal decompression for the relief of increased intracranial pressure.

Hemorrhage for a ruptured middle meningeal artery should be checked as

soon as it is diagnosed. The treatment is surgical.[6]

X-ray examinations should not be con-

FIG. 3. Rupture of superior longitudinal sinus. Bilateral subdural hemorrhage. This patient had been struck over the vertex with an axe helm and died in fourteen hours.

considered, from an intracranial stand-point, as cases of mild concussion. They were hospitalized for a period which

FIG. 4. Subdural hematoma. Treatment by saline irrigations through trephine openings. Bilateral exploration of the dura. X-ray taken one year after recovery.

sidered early in the treatment of these injuries, but should be postponed until the patient is out of danger, except where there is a question of extradural hemor-rhage.[7] A positive x-ray finding of a linear fracture crossing the path of the middle meningeal artery or its branches may be of use and therefore excusable in instances of this kind.

As long as the patient with a depressed fracture or bloody spinal fluid is holding his own, or is showing improvement under treatment, operation should be postponed for a few days. The patient will have a better chance for recovery.

The postoperative treatment is largely that of combating increased intracranial pressure. Of our 200 cases, 176 were classified as non-surgical. These varied in seriousness from momentary loss of consciousness with apparent complete re-covery in a few hours, up to prolonged unconsciousness, two weeks in one instance, with definite evidence of severe structural damage. Many of this group had injuries to other parts of the body. Those un-conscious for less than thirty minutes were

average 4.1 days. (Table VI.) Some of these cases were concussions as defined by Munro,[7] i.e., "a mechanical derangement of molecules within the nerve cells causing

TABLE VI
TREATMENT OF CASES OF MILD CONCUSSION

Non-surgical cases..................	176
Mild concussion...................	74
Observation* (7 sequelae).......	55
Dehydration..................	19
(7 sequelae)	
Corporal fractures.................	12
Ruptured hollow viscus............	1
Deaths...........................	0

* Included frequent recordings of blood pressure, temperature, pulse and respiration.

momentary loss of function" while the others must have had mild, but definite, brain damage, probably slight edema and congestion. The occurrence of sequelae in 19.2 per cent suggests this.

Fifty patients were admitted to the hospital in an unconscious state. These offered the greatest problem. Concussion, delirium, aphasia, stupor, all with or without shock and hemorrhage, were present in this group. Twenty-one had additional injuries. In evaluating these

cases the degree of consciousness is perhaps the most valuable single observation.[6,7] A differentiation between stupor and aphasia is important. Loss of sphincteric control and the presence or absence of the various reflexes are of prognostic value. Negative symptoms are just as important as positive symptoms in that they aid the observer to follow the progress of the case more intelligently. "Hemiplegia and monoplegia, when caused by depressed skull fractures, are present from the moment of injury."[8] The relationship between pulse pressure and pulse rate should be recorded at frequent intervals. These observations, together with a spinal fluid pressure reading, give more information regarding the intracranial state than does the x-ray. A study of the eye-grounds is useful after the first twenty-four hours.

The treatment of the unconscious patient should begin from the moment he arrives at the hospital, or ideally as soon as the physician arrives at the side of the patient. Peace and quiet are needed. He should be placed in a warm, flat bed, with his clothes on if necessary. To recapitulate shock is the first consideration. Patients presenting pulmonary edema or who are bleeding from the nose or mouth should be turned on the abdomen and have a pillow placed under one shoulder. At the same time the foot of the bed is elevated to facilitate postural drainage. Treatment based on the assumption that "death from a head injury is due to changes brought about in the physiological relationship within the cranial cavity"[9] is instituted. Increased intracranial pressure, if carried far enough, produces cell death by anoxemia, and anoxemia occurs when the diastolic pressure reaches 40 mm. of mercury.[10]

The patient not infrequently loses or wins his fight during the first twenty-four hours. Every effort should be made to keep the patient going, by helping nature with her heavy burden until she can carry on unassisted. The diastolic blood pressure must be kept up and the intracranial pressure must be kept down. Drugs, the continuance of which might be harmful later on, hypertonic fluids, etc., are permissible during this period. Oxygen through a nasal catheter, sponges for fever and other such treatments may be life saving. While these treatments are under way, such minor details as bleeding ears may be attended to, lest they give trouble later on. Table VII shows the methods used and the results obtained in this series of cases. Intravenous hyper-

TABLE VII
METHOD OF TREATMENT OF SEVERE HEAD INJURIES

	No. of Cases	Percentage
Total cases of non-surgical treatment	93	
Observation	49	52.7
Mortality		30.6 (corrected 20.9)
Sequelae		26.5
Lumbar puncture alone	12	12.9
Mortality		41.7 (corrected 27.3)
Sequelae		41.7
Dehydration alone	13	14.0
Mortality		15.4 (corrected 7.7)
Sequelae		53.8
Dehydration & occasional lumbar puncture	19	20.4
Mortality		26.3 (corrected 21.1)
Sequelae		36.8
Repeated lumbar puncture and dehydration	15	
Mortality		13.3
Sequelae		40.0

tonic glucose solution was used, with dehydration in only a few instances. Dehydration and repeated lumbar punctures were found to be more effective than the other types of treatment mentioned.

Fay's adage "when the pulse pressure approaches the pulse rate, that is the time to dehydrate"[10] has been followed, in preference to the old adage "if pulse pressure crosses the pulse rate, that is the time to decompress." The treatment of our recent cases has largely followed the teachings of Fay. Dehydration when

carried too far produces a toxic dehydration.[11] A fat person can stand more dehydration than can a thin person.

Repeated lumbar punctures have been performed upon patients presenting bloody spinal fluid on the grounds the red blood cells produce arachnoiditis with subsequent blockage of the arachnoid pathways and filter.[12] Those patients found to have an increased intracranial pressure at the time of the diagnostic tap, have also had repeated punctures for the purpose of reducing intracranial pressure.

Sucrose, 50 per cent, in 50 c.c. doses, has been used in two cases, one of which was definitely benefited by its use. The late elevation of intracranial pressure seen following the intravenous use of hypertonic glucose has been shown by Masserman[13] not to occur after the use of sucrose, his argument being based upon the fact that sucrose is not extracted from the circulation into the tissues, and that it induces a marked diuresis. Hahn and his associates have found from clinical experience with twenty-five cases of acute brain injury that sucrose given intravenously replaces glucose for osmotic therapy.[14]

The problem of sedation is sometimes great. When possible, the bromides, barbiturates, and paraldehyde should be used and not opiates. We have considered morphine and H. M. C. necessary in some instances. A part of the objection to this drug can be overcome if the patient is carefully watched.

TABLE IX
INCIDENCE AND TYPE OF SEQUELAE

Cases followed after discharge....... 74
  Well......................... 21   28.4 per cent
  Mild sequelae................... 25 ⎫
  Moderate sequelae............... 6 ⎬ 71.6 per cent
  Severe sequelae................. 22 ⎭

The prognostic factors, and the incidence and type of sequelae are shown in Tables VIII and IX. Mild sequelae were evidenced by headache, dizziness, or slight nervousness. Moderate sequelae were considered irritability and loss of enthusiasm. Severe sequelae were indicated by personality change, convulsions, blindness, insanity, etc.

Table X shows the mortality rates, corrected and uncorrected. The corrected mortality rate excludes deaths occurring in the first twenty-four hours.

TABLE X
MORTALITY RATES

	Gross Rate, Per Cent	Corrected, Per Cent	Further Corrected, Per Cent
Entire series—200 cases......	16.0	9.9	4.9
113 cases of past two years...	12.4	8.0	4.7
Mild head injuries—90.......	0		
Severe injuries—110.........	29.1	18.8	10.9
55 cases of past two years....	25.5	17.0	10.2
Cases under 12 years........	11.9		
13–21 years.................	8.7		
22–35 years.................	14.3		
35–50 years.................	21.9		
Over 50 years...............	30.4		

SUMMARY

1. A series of 200 cases of head injury has been studied.

2. The treatment has been surgical in nineteen cases and non-surgical in 181 cases.

3. The lowest mortality, in the seriously injured, occurred in the cases treated by repeated lumbar punctures and dehydration.

TABLE VIII
PROGNOSTIC FACTORS

	No. of Cases	Deaths	Per Cent Mortality
Convulsions on admission.....	10	4	40
Unconscious on admission.....	50	20	40
Aural bleeding...............	17	8	47.1
Right aural bleeding..........	..	..	66.7
Left aural bleeding...........	..	..	33.3
Bilateral aural bleeding.......	..	..	50
Fractured skull...............	102	31	30.3
Bloody spinal fluid...........	25	12	48.0

4. The most severe sequelae occurred in those cases having the most serious injuries.

5. The mortality can be reduced by the application of therapy based on physiologic principles and careful bedside observation.

6. No case should be considered as lost from the moment of injury, although this is true in a certain definite number of instances through virtue of the fact "that therapy has little influence on those cases in which actual brain damage is primarily responsible for the clinical picture."

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SELECTION OF CASES FOR TRANSURETHRAL RESECTION*

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ANY discussion of the selection of cases for transurethral resection must be variable, since the attitude of a surgeon beginning in this work must of necessity be entirely different from that of operators who have supervised many hundred cases; such men as Alcock, Bumpus, Davis and Thompson are resecting all types of obstructive lesions. It appears, therefore, that the selection of cases depends entirely upon the individual operator's experience and his attitude toward the position of transurethral resection in the operative field.

Almost everyone was caught in the wave of enthusiasm that swept the country in 1933, in which operators without sufficient experience attempted the resection of the enormous type of prostatic enlargement which the beginner should reject without hesitation. It was inevitable that in our first fifty cases the greatest difficulties and the highest mortality were encountered.

In the selection of cases it is essential to begin with the small median bars or median lobes requiring the removal of only the minimum amount of tissue. As the operative technique improves the smaller types of benign adenomas may be attempted. In two of the patients encountered a generalized fibrosis of the entire bladder neck and posterior urethra was present. Resection in this type of case has not proved entirely satisfactory. The removal of tissue under these circumstances is difficult with the punch instrument due to the difficulty of engaging the hard, resistant fibrous tissue. It is manifestly impossible to remove all of the fibrosis by this method, so that transurethral operations in these cases must be followed by dilatation of the posterior urethra. Resection will relieve the urinary retention, but frequency of urination is likely to persist.

Careful study is required at first to determine the position of the obstructing tissue. Enlargements of the anterior lobe and the anterior portions of the lateral lobes must not be overlooked, since failure to remove tissue in these positions may frequently account for poor results. At the present time, therefore, I am resecting all types of benign obstructive lesions with the exclusion of the very large prostates (those estimated to weigh more than 100 Gm.). Since it is possible under the present set-up to remove between 20 and 30 Gm. of tissue at one sitting without great difficulty, it is best to select cases in which obstruction can be relieved with the removal of 60 Gm. of tissue or less. Considerable reliance is placed upon rectal examination to determine roughly the total bulk of tissue. The group of cases now considered suitable for transurethral resection constitutes roughly 95 per cent of the benign obstructive lesions encountered by the writer.

Where there are prostatic calculi the response to transurethral resection is particularly good. Occasionally the prostate gland will be reduced to a hollow sack filled with small calculi and upon the removal of the intraurethral portion of the gland the calculi may frequently be scooped out of the prostatic bed with the beak of the resectoscope. The remaining small portion of the obstructing gland is then trimmed off.

A good percentage of all obstructions at the bladder neck are complicated by the

presence of bladder calculi. If the calculus and the obstructing gland are both small, the calculus may be crushed with the

be done with practically no risk as compared with the mortality of suprapubic enucleation.
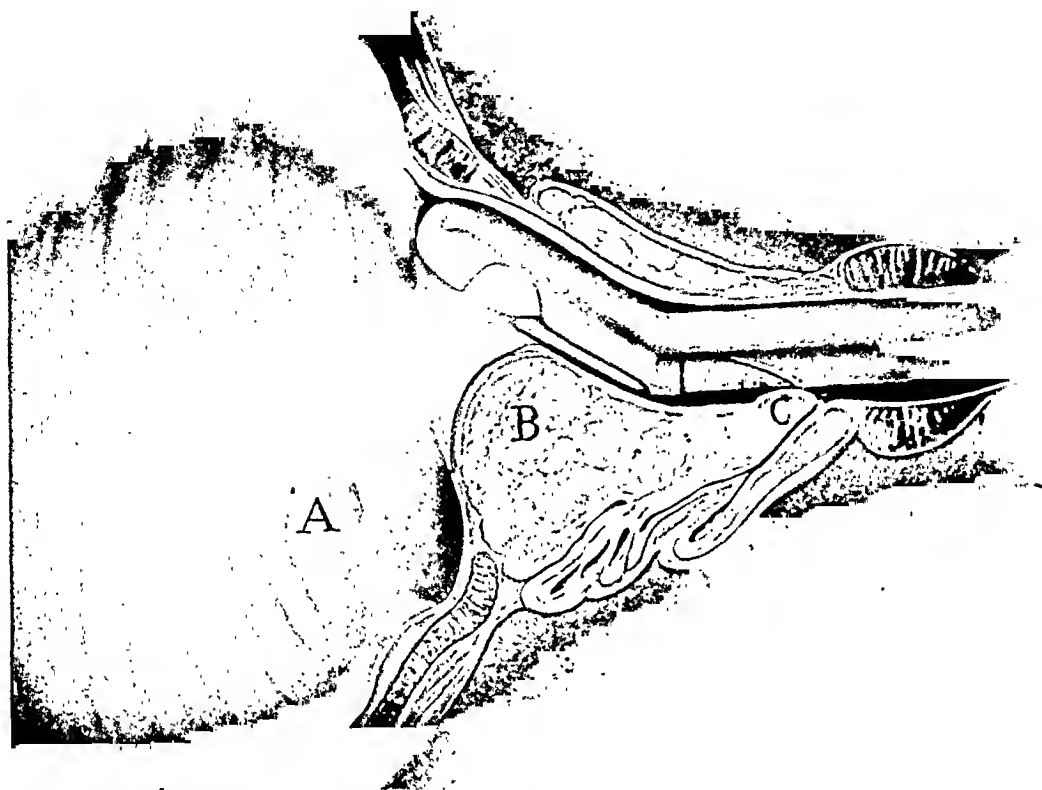
FIG. 1. Landmarks used in transurethral resection: A, ureteral meatus. B, obstructing prostatic tissue with verumontanum. All of the cutting is done between the verumontanum and the ureteral meatus.

lithotrite and the obstructing tissue removed by the transurethral method. In dealing with this type of case I strongly advise dealing with the calculus first; otherwise it will interfere with the movement of the resectoscope during the operation. It may also interfere with the drainage of the indwelling catheter following operation, and after the catheter is removed, the calculus will have a tendency to fall into the funnel-shaped excavation at the bladder neck.

Stones over 3 cm. in size should be removed suprapubically, with transurethral resection after ten to fourteen days of suprapubic drainage. I do not believe small glands should be enucleated suprapubically simply because a suprapubic cystotomy wound is present. Transurethral operations under these circumstances may

The treatment of large diverticula of the bladder associated with an obstructive lesion at the bladder neck is a subject of controversy. The majority of these cases may be completely relieved clinically by the removal of the obstruction, although there is undoubtedly a certain number in which it is necessary to dissect out the diverticulum. Three cases of large diverticula have been treated by resecting the obstructing bladder neck, the capacity of the diverticula being respectively 8, 16, and 22 ounces. The first two patients mentioned emptied their bladders satisfactorily, with no residual urine, eight weeks after operation; the third patient has been observed for only twenty days postoperatively and the amount of residual urine varies from 2 to 4 ounces (as compared to 22 ounces

before operation). I know of no objection to trying transurethral relief of bladder neck obstruction in these cases with the

factory. However, the hard, scirrhous type of carcinoma is much more difficult and presents almost the same problem as the
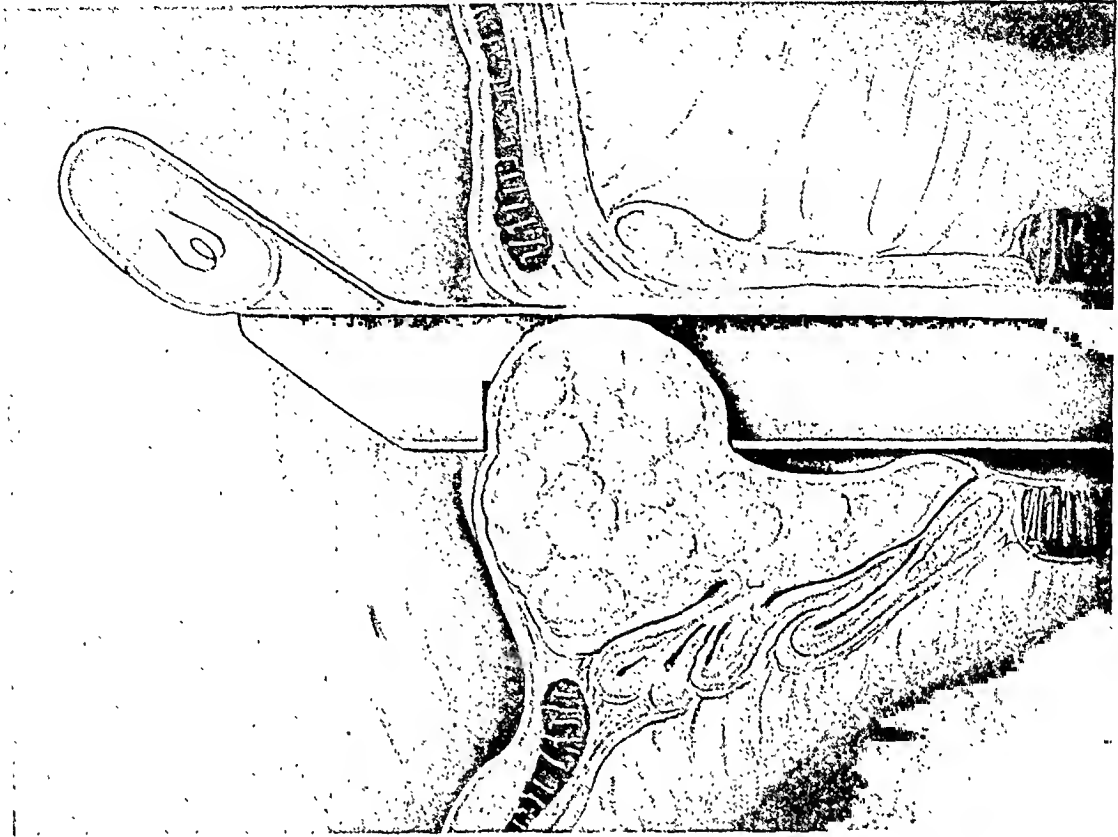
Fig. 2. Obstructing tissue in the fenestrum of the punch instrument.

idea in mind of resecting the diverticulum at a later date if necessary.

In this series, the only female with bladder neck obstruction was a highly nervous spinster with an enormously hypertrophied internal sphincter. The imbalance between the neuromuscular apparatus had developed to such an extent that she had almost complete retention of urine for six days before operation. We realized we were treating effect rather than cause, but the distress was so great that it was decided to resect the internal sphincter, by removing one large bite from the midline. This has been followed by two years of relief.

Transurethral resection is attempted in all cases of carcinoma of the prostate. Resection of carcinomas for the relief of obstruction is, as a rule, very satisfactory. Some of the glands appear to be avascular and cut like cheese, and in these cases resection is quite easy and very satis-

generalized fibrosis of the bladder neck. Whether or not the instrumentation stimulates metastases, I am not in a position to say, but the relief of obstruction in this hopeless condition is an important factor.

The presence of large amounts of residual urine should not deter one from transurethral resection. Acute retention may be caused by small glands and after adequate decompression these glands may be resected just as successfully as those with a small degree of retention. On the other hand, everyone has seen large glands producing relatively little obstruction. Relief of the symptoms of dysuria, frequency and nocturia may be the outstanding reasons for seeking relief; these are often as important an indication as large amounts of residual urine.

The above observations are based upon a consecutive series of 213 operations on 170 patients. About three-fourths of these operations were done with the Braasch-

Bumpus punch instrument. The last forty-two operations were done using the new Thompson "cold punch." This instrument has proved to be much more efficient than any used previously. The mortality rate has been particularly gratifying, only six deaths having occurred in the entire series. Three of the deaths occurred in malignant cases, leaving a mortality of less than 2 per cent in the benign group.

The last 101 consecutive cases have been operated upon without a fatality.

The clinical results have been very satisfactory. Postoperative complications and morbidity have been reduced to a minimum. Over one-half the patients were able to leave the hospital on the sixth postoperative day.

SUMMARY AND CONCLUSIONS

1. The selection of *cases* depends entirely on the operator's experience and ability. In the first fifty cases we should select only the easiest ones or those requiring the removal of the minimum amount of tissue.

2. Diverticula of the *bladder* will usually take care of themselves if the obstructing lesion is removed.

3. The cold punch operation has proved to be very satisfactory in almost all types of obstructive lesions. The results are good and the mortality is low.

In fractures of the distal end of the humerus integrity of circulation and nerves should be determined before reduction is undertaken.

PERSONAL EXPERIENCES WITH GAS BACILLUS INFECTION*

A REPORT OF FORTY-ONE CASES

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MANY men have contributed to our knowledge of gas bacillus infection. With the appearance of the "germ theory" of disease, organisms found associated with gas gangrene were investigated by such men as Pasteur, Novy, Koch, Welch and Weinberg. The clinical investigation of this disease has been described very well by such early workers as Stolz (1902), Cramp (1912), and Simonds (1915).

Interest was aroused in gas gangrene during the last great war and much literature was written about it. Possibly the best articles are the reports of the Surgeon General of the United States Army and the Great Britain Medical Council. Such investigation has provided a basic knowledge of the etiologic factors involved and pathologic changes which take place in the diseased tissues.

The extensive distribution of various gas-producing organisms is now generally recognized. Manson demonstrated that more than 34 per cent of chronic ulcers harbored gas bacilli. Roberts, Johnson and Buckner grew cultures of anaerobic spore-bearing bacilli from the unprepared abdominal wall skin of more than 21 per cent of persons examined. An abdominal wall gas gangrene resulted from diversified types of abdominal operations in twenty-one cases recorded by T. G. Orr. However, although the existence of these organisms is an accepted fact, results of treatment in the cases remain highly unsatisfactory. A mortality rate of 49.7 per cent was reported recently by Millar in an analysis of 607 collected cases of gas bacillus infection occurring in civil life. The American Expeditionary Forces in France reported a mortality rate of 48.152 per cent. These surveys are only unique in their vastness; the percentages quoted are borne out by countless similar reports.

Naturally the high mortality in these cases has caused many methods and combinations of methods to be utilized in treatment. The tragedy is that the acute necessity for this experimentation has caused it, to a certain extent, to defeat its own ends. So many methods of treatment are tried on the same gas infection case that estimating the value of each agent used becomes increasingly difficult.

J. F. Kelly recently studied the status of x-ray treatment in gas gangrene. He believes its use is valuable in both limb and trunk cases, and he begins treatment as soon as gangrene is suspected and continues it throughout the course, twice daily for at least three days. From his viewpoint, amputation seems detrimental, or at least unnecessary. He considers gas bacillus serum, local antiseptics, local minor surgery, and x-ray much safer, since all deaths in his series occurred in cases with amputation of an extremity, while all those having no amputation survived. Of the thirteen cases where amputation was utilized, five patients died and eight recovered, while of twenty-one with extremity involvement and no operation, none died. In two cases of this series no serum was used and both patients recovered, although one developed tetanus after the gangrene had subsided.

G. E. Konjetzny (Dortmund) observes that serum effect is difficult to estimate,

and that some of the alleged benefit may be from the direct surgical treatment. However, after some personal experiences with these gas infections he believes serotherapy is effective.

The startlingly high mortality following treatment has inspired the suggestion of many procedures to cure this disease and consequently few conditions have aroused so much interest and so much controversial discussion. When that which is not established is done away with, the majority of the controversies simmer down to a few accepted points. The treatment of gas bacillus infection readily divides itself into two methods of therapy, prophylactic and active, both of which are preëminently operative. Early débridement and the use of delayed primary suture have brought the incidence of gas infection down to a low percentage.

TABLE I

GAS BACILLUS INFECTION IN FORTY-ONE CASES

	Total Cases	Recoveries	Died
Surgery done for existing gas gangrene of an extremity.	1 débridement of arm. 3 amputation of arm. 3 amputation of legs. (2 legs on one patient) — 7	7	None
Amputation plus serum. Extremity cases.	6	5	1
Serum in septicemia. One case a gunshot wound; the other two cases contusions.	3	0	3
Serum plus incision of extremity. Septic cases.	5	1	4
X-ray treatment used in abdominal wall cases and where amputation seemed inadvisable.	14	4	10
Miscellaneous..............	6	4	2
Total cases..............	41	21	20

Active treatment of an existing gas bacillus infection has consisted of amputation, open incision, débridement, serum

therapy and x-ray. The results of these methods of treatment or varying combinations of methods have been previously mentioned. That some of these methods have not been satisfactory and others have been, according to the literature reviewed, is most interesting. We wish to present our own personal cases and the mortality resulting in the various methods of treatment used. An analysis is summarized in Table I.

The following cases were seen and treated by the Junior author, on the x-ray Service of Dr. C. H. Warfield at the Cook County Hospital, and from the Surgical Service of Dr. E. P. Coleman, Canton, Illinois, since the World War.

CASES REPORTED

In the first group of cases, nothing in the way of treatment was done for the patient except surgery. Gas infection was present in an extremity in all seven cases. Clinically, these cases were those of gas gangrene of an extremity from twenty-four to ninety-six hours in duration. Five of the cases were cultured and Bacillus welchii was discovered. Immediate amputation was performed and no persons died. One of these patients had gas gangrene of both legs. Both legs were amputated and the patient recovered.

Six cases of existing gas infection received serotherapy in addition to surgery (amputation). Only one death occurred, and we believe this man had gone too long for help, since an extensive infection and septicemia had developed. All six cases were clinically and bacteriologically gas bacillus infections.

Serotherapy alone was unsuccessfully used in three cases of gas bacillus septicemia, all of which proved fatal. One case was the result of a gunshot wound of the abdomen; the other two followed extensive lacerations of extremities. Post-mortem examination showed that all the patients died of septicemia resulting from gas bacillus infection.

In five cases diagnosed as septicemia, serotherapy was used, plus extensive débridement of the extremity, but only one patient recovered. That case was probably not one of septicemia. Recovery occurred with late amputation (seventh day).

X-ray treatment was used alone in fourteen cases, resulting in four recoveries and ten deaths. Three developed gas bacillus infection of the abdominal wall following operation and were lost. Postmortem examination showed that these patients died of gas bacillus septicemia. One developed gas gangrene postoperatively, following a gunshot wound of the abdomen. X-ray was tried, but again to no avail. Autopsy showed a generalized gas bacillus septicemia. Ten of the patients had a far-advanced gas bacillus infection of an extremity. Amputation seemed inadvisable at the time and x-ray was tried alone. Six died of septicemia. Four of these six were brought to autopsy and showed gas bacillus septicemia as the cause of death. In the four cases that responded to x-ray, wide opening and amputation resulted in recovery.

Two deaths resulted in six cases which received varied combinations of treatment. One patient had a gunshot wound of the abdomen, with seventeen perforations of the ileum. After operation and repair, he was given serotherapy, but died of generalized septicemia of gas bacillus type, as shown at autopsy. There was no peritonitis present. In another case, a gunshot wound of the thigh developed gas gangrene. X-ray, débridement, and serotherapy were tried but the patient died of a gas bacillus sepsis. One man developed gas bacillus infection of low virulence in a clean amputated stump, after amputation had been performed for diabetic and arteriosclerotic gangrene. The amputated stump was laid wide open and the patient was given serotherapy, with recovery. Later, a secondary amputation was necessary. Three of this group had gas gangrene of an extremity from gunshot wounds. Amputation and serum were used, but

gangrene developed in the amputated stump, requiring a secondary amputation, after which recovery took place.

DISCUSSION

Considering the cases as a whole, we find a mortality of 48.7 per cent. These cases were taken as they came, and usually were seen in a well advanced or very late stage of the disease.

When further analysis of the individual deaths was completed, autopsy showed that these deaths were due to gas bacillus septicemia. Our results coincide with those of others in disclosing that acute gas bacillus infection may rapidly become a generalized septicemia.

In local forms of gas infection progress of extension is not by the blood or lymph stream, but by direct development through the muscle and fascia involved. Such local types may get into the blood stream and cause a septicemia. Consequently, the prophylactic treatment of these gunshot wounds and acute traumatic cases is complete débridement. If the gas infection is local and in a local muscle group, probably open incision and excision are enough for cure. In the advanced case, as most of these were, amputation, we believe, is a life-saving measure if septicemia has not set in. Amputations are not always successful because the gas infection has already become a septicemia. We believe that promptness of diagnosis and the institution of early amputation are the factors of prime importance if this condition is to be averted.

Dr. George Davis first demonstrated the importance of early recognition of gas infections by use of x-ray findings (1916), and we find this a great help in early diagnosis as well as assisting in determining early treatment. We find that in the cases we have to report, when amputation is performed and a septicemia is already present, the infection travels rapidly to a fatal termination without any benefit from removal of the original source of infection.

CONCLUSIONS

We believe that in handling gas bacillus infections no single remedial agent should be solely relied upon. Polyvalent serotherapy may be of value when associated with active surgery, but considering the great number of strains of anaerobic organisms, as shown by Weinberg, it is doubtful whether serotherapy would meet all contingencies. We believe that early recognition and immediate treatment of gas bacillus infections are absolutely essential and that x-ray findings may be of great aid in expediting diagnosis of gas infection.

This group of cases is, of course, too small to let us draw definite conclusions, but we fail to see any help for these individuals through early diagnosis and proper surgery. The added influence of serotherapy and x-ray therapy may also be used, but we believe they are not determining factors unless proper surgery has been done early in the progress of the disease. X-ray therapy alone was disappointing and failed to give the results we had been led to expect.

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FURTHER STUDIES ON THE INTRAPERITONEAL USE OF BOVINE AMNIOTIC FLUID IN ABDOMINAL SURGERY*

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THE intraperitoneal administration of bovine amniotic fluid at the time of operation has held our attention for the past five years. We have employed it chiefly in the hope that we might be able to promote a smoother postoperative convalescence, eliminating or at least ameliorating some of the factors, such as nausea, gas pains, and distention, which prove so annoying to the patient. This course was suggested by Johnson's observation[1] that the agent under consideration decreased distention, shortened the period of emesis, and hastened resolution when used in experimental animals.

In a previous report[2] published in 1935, we felt that enough proof of its beneficial effects had been adduced to justify a second series of cases.

As in the previous study, this work has been carried out on the Gynecologic Service of the Third (New York University) Surgical Division of Bellevue Hospital. The agent used was a concentrated sterile fraction of bovine amniotic fluid, known as amfetin. The technique of administration was described previously.[2] It consisted essentially of introducing 400 c.c. of previously warmed amfetin into the abdomen just before tying the final peritoneal suture.

Preceding the administration of amfetin to any of our patients, we employed it in a number of experimental animals that had been subjected to various forms of severe peritoneal trauma and irritation such as might be encountered or produced during major surgical procedures. A similar group of animals was subjected to the same operative procedure, but had normal saline administered intraperitoneally. Both groups of animals were reoperated on several times at intervals of three weeks and all finds were carefully noted. Briefly, the results were as follows:

1. Both groups of animals showed adhesions three weeks after the initial operation, but the animals treated with amfetin showed fewer adhesions, which were less dense and easier to separate. This coincided with the results of a previous study made by Lacey.[3]

2. Repeated separation of adhesions at subsequent operation resulted in more numerous and denser adhesions in the group of cases receiving saline, while the group receiving amfetin showed fewer and thinner adhesions.

3. The animals receiving amfetin survived twice as many operative procedures as the group in which saline was used.

4. The amfetin group presented a better postoperative appearance, retained fluid and solid food earlier, and was more active than the controls.

With these observations in mind, we set about outlining a possible course of study on the human. Bearing in mind the infrequency of reoperation on this service, with the resultant paucity of information as to the effects of any agent in modifying the formation of adhesions, we undertook the clinical study of amfetin as related to postoperative convalescence.

Out of 100 consecutive patients having a celiotomy, the fifty presenting the most marked pelvic pathology at the time of operation were given amfetin, and the remaining fifty were used as controls.

It was found in this first study that of the amfetin group, 74 per eent of the patients had dense adhesions at the time of operation, while 10 per eent of the eontrol group were similarly eomplieated. The postoperative results were eneouraging, in that nausea, vomiting, distention and gas pains seem definitely to be deereased by the use of amfetin. This was in aeeord with the findings of Trusler,[4] who states that "these patients tend to enjoy a smooth postoperative course."

In addition to these and other measured findings, there were several subjeetive faetors whieh were rather elusive when the time eame to evaluate them. For example, it was thought that a patient who had reeeived amfetin at the time of operation subsequently had a softer abdomen, expressed a desire for food earlier, and as a rule was brighter than a similar control patient. It was also thought that most of the amfetin patients more nearly approximated normal posture when allowed out of bed. However, it should be borne in mind that these are impressions only, and not definite findings.

tors whieh we were most desirous of determining.

The eases treated with amfetin in this second series were, as a rule, not selected, but taken more or less alternately with the eontrol eases. It must be added, however, that if a partieularly diffieult case was eneountered, that patient usually received amfetin. Control patients numbered 125, while 102 reeeived amfetin, making a total of 227 patients observed.

The surgeons, anesthetists, and operating room teehnique were essentially similar in both groups. The anesthetic agents were nitrous oxide and ether.

With the exeeption of one case of lobar pneumonia in eaeh group, there were no major eomplieations. Wound infeetions were equal in eaeh group.

Tables I to VII summarize the other results. In Table I are listed the operative diagnoses in the last two groups. There is a preponderanee of ectopies in the eontrol group, and of fibromyomata in the amfetin group. Otherwise there is no marked differenee in the two categories of patients.

TABLE I
OPERATIVE DIAGNOSIS

	Control	Amfetin
Fibroids	24	30
Fibroids with adnexal disease	9	7
Adnexal disease	32	28
Retroversion	24	15
Ovarian cyst	13	9
Endometriosis	0	1
Fundal malignancy	0	1
Ectopic pregnancy	14	4
Appendicitis	0	1
Perforation of uterus	2	0
Intrauterine pregnancy	7	4
	125	100

With these facts as a background, the present study was undertaken in an effort to substantiate or modify our previous conclusions. Different standards were adopted which tended to emphasize those fac-

TABLE II
OPERATIVE PROCEDURES

	Control	Amfetin
Complete hysterectomy with salpingo-oöphorectomy	1	1
Supracervical hysterectomy	16	16
Supracervical hysterectomy with salpingo-oöphorectomy	20	29
Salpingo-oöphorectomy	33	21
Salpingectomy	11	8
Tubal plastic operations	3	3
Suspension of uterus	15	7
Suspension of uterus and adnexa	12	8
Myomectomy	1	4
Hysterotomy	7	4
Repair of perforated uterus	2	0
Appendectomy	0	1
Little's operation	4	0
	125	102

In Table II are listed the major or most important operative procedures performed in each case. Here again there is no marked difference, except in the number of uterine

suspensions performed on the control patients, and the slightly greater number of hysterectomies performed on the amfetin patients.

TABLE III
ADHESIONS

	Control, Per Cent	Amfetin, Per Cent
Adhesions present...............	39.70	53.84
Adhesions absent................	60.30	46.16
Dense adhesions................	13.6	20.6

In Table III it will be noted that approximately 40 per cent of the control group were found to have adhesions at the time of operation, whereas 54 per cent of the amfetin group were similarly affected. Also, it will be noticed that dense adhesions, of a fibrous type, were present in 13.6 per cent of the controls, and 20.6 per cent of the amfetin patients. This would seem to indicate that the group of patients treated with amfetin presented slightly greater possibilities for a disturbed postoperative course than the control group. This difference was present in spite of an effort to use this substance on alternate cases.

It might be well to add here that the filmy, easily separated type of adhesion is not included in these statistics. The incidence of dense adhesions seems high in both groups, since these patients were studied at Bellevue Hospital, where the result of extensive pelvic inflammation is commonly encountered.

In Table IV we have the average daily measurements of the abdominal circumference at the level of the umbilicus, these measurements being taken immediately postoperatively, and on the afternoons of the first, second, third and fourth postoperative days. Analysis of these figures shows 21 per cent more distention, as measured in inches, in the untreated or control group. Actually, as can be seen from the figures, this difference represents only a small increase of distention in the control group.

TABLE IV
AVERAGE ABDOMINAL MEASUREMENTS (DISTENTION)

	Control, Inches	Amfetin, Inches
Immediately post-operative.......	29.59	29.31
24 hours post-operative..........	30.50	30.07
48 hours post-operative..........	30.91	30.58
72 hours post-operative..........	30.78	30.35
96 hours post-operative..........	30.64	30.17

VOMITING		
Number of attacks first 24 hours (average).....................	1.5	1.25
Number of attacks after 24 hours (average).....................	1.43	.73

The second part of the table shows the average number of times patients in each group vomited during the first twenty-four hours, and also during the subsequent ninety-six hours. During the first twenty-four hours the amfetin patients enjoyed a 17 per cent advantage. During the subsequent ninety-six hours, the amfetin patients vomited only half as many times as did the control patients. It is interesting to note in this connection that Lacey,[5] in a similar study, found that the duration of vomiting in the amfetin group was 11.84 hours, while in the controls it was prolonged to 18.14 hours. He also found that when spinal anesthesia was employed, the amfetin group averaged vomiting 1.25 hours, while the controls extended this period to 19.14 hours. This forces one to wonder if most of the nausea and vomiting found in the amfetin group of the present study is not due to the effects of the anesthetic employed.

The results in Table V are not so encouraging, for while the amfetin group shows a slight advantage in the number of patients who suffered no gas pains, the severe seizures were more numerous in the amfetin group. This is contrary to our findings in the first series of patients studied. Likewise, the moderately severe attacks in the amfetin group, while less numerous than in the controls, are still

TABLE V

	Control, Per Cent	Amfetin, Per Cent
Gas Pains		
Slight	27	29
Moderate	44	33.5
Severe	7	7.5
No pains	22	30.0
Nausea		
Slight	24.5	31.7
Moderate	31.7	22.1
Severe	9.6	6.7
None	34.2	39.5

much more frequent than in our first series of cases. The second part of the table shows some advantage for the amfetin patients as far as nausea is concerned, but again there is a discrepancy between the figures in this series and our first one. The increase in the slight columns has been referred to before in discussing our theory of shifting as a result of modification of the usual reaction.

TABLE VI

	Control	Amfetin
Average highest pulse rates		
First 24 hours	109	109
Second 24 hours	109	107
Third 24 hours	102	103
Fourth 24 hours	96	95
Average of highest temperatures		
First 24 hours	100.7°F.	100.7°F.
Second 24 hours	100.7°F.	100.6°F.
Third 24 hours	100.2°F.	100.2°F.
Fourth 24 hours	99.6°F.	99.7°F.

Table VI summarizes the average temperature and pulse rates for the two groups. The similarity of the figures precludes any suggestion of a beneficial or deleterious effect on these factors.

We also find a striking similarity in the pre- and postoperative blood pressures of both groups. The average duration of anesthesia and the average operating time is slightly longer in the amfetin group. The average number of catheterizations in the control group exceeded those of the amfetin

group by 22 per cent. Also it will be noticed that the amfetin patients began voiding about six hours earlier postoperatively than did the control patients. Peristaltic sounds were heard seven hours sooner in the average amfetin patient than in the average control.

TABLE VII

	Control	Amfetin
Blood pressure (average)		
Preoperatively	119/76	122/79
Postoperatively	118/75	121/77
Time anesthetized (average)	64.75 minutes	68.33 minutes
Operating time (average)	55 minutes	59.6 minutes
Average number of catheterizations per patient	1.81	1.41
Average number of hours before voiding post operative	24.70 hours	18.71 hours
Average number of hours before peristaltic sounds were heard	46	39.3

SUMMARY

1. One hundred and two patients received 400 c.c. of amfetin each at the conclusion of gynecologic celiotomies, the agent being introduced into the peritoneal cavity.

2. One hundred and twenty-five patients having similar operations under similar conditions, but not having amfetin administered, were used as controls.

3. The postoperative clinical condition and reaction of patients was closely observed and, where possible, these factors were measured in terms of known units.

CONCLUSIONS

1. The intraperitoneal administration of a concentrated sterile fraction of bovine amniotic fluid at the time of operation has no appreciable effect on blood pressure, pulse, temperature or number of wound infections.

2. The effect on postoperative adhesions in the human is not known to the authors,

none of our 227 cases having come to reoperation.

3. Normal intestinal motility and normal contraction of the bladder seem to return to normal sooner when amfetin is administered.

4. The intraperitoneal use of amfetin at the time of operation holds definite promise of affording the patient varying degrees of relief from nausea, vomiting, gas pains and distention.

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Supracondylar fractures of the flexion type are infrequent. They usually require open reduction.

IMPORTANT RECKONINGS IN BILIARY SURGERY*

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IN spite of the progress made in the management of biliary disease, there are so many patients who are not relieved of their difficulties after they once have submitted to treatment, that what confidence once rested in the attending physician is lost, and the difficulties of the problem are magnified. There is very little to be gained in the study of good results, but an honest and painstaking investigation of poor results obtained may lessen their incidence and otherwise convert them to satisfactory ones.

The greater contributions to surgical advance in recent years have apparently come by way of the biochemical and physiologic laboratories rather than by way of the operating room. It is not intended that this paper shall be all inclusive; a great many interesting features concerning problems associated with biliary surgery have been excluded from this discussion.

In a five-year study of 249 biliary cases in a well rated private institution, there were:

	No. of Cases	Deaths	Per Cent Mortality
Acute cholecystitis.........	63	11	16
Chronic cholecystitis.......	127	16	12½
Cholelithiasis..............	59	6	10.1
	249	33	13.2

This could reasonably be taken as an index of what is actually accomplished by present preoperative and operative routine, but these figures seem altogether too high. A further review of postoperative morbidity would also show some astoundingly poor clinical results with treatment by present methods.

The results on the average service, in the average municipal hospital, are better by far than those of private institutions, because charity patients may be kept in the hospital preoperatively, careful laboratory determinations are not wanting and medical coöperation is always available without cramping the surgeon's freedom in preoperative study.

While some clinics report very inspiring results in the management of biliary disease, the profession as a whole has no cause to rejoice over the results now obtained. The bulk of surgery is not being done under conditions that obtain in better clinics. In spite of repeated pleas for lessening the mortality and morbidity in the treatment of diseases of the gallbladder and bile ducts, too small a number of converts have been made to this cause.

Poor results may be enumerated briefly as:

1. The fatal termination of a case.
2. Recurrence of symptoms which antedated treatment and which offered the chief indication for treatment.
3. Recurrence of pathology which the treatment instituted was intended to eliminate: bile stasis, biliary dyskinesia, common duct obstruction and intrahepatic calculi.
4. The occurrence of an aftermath more disturbing to the patient than the symptom complex for which originally the patient sought relief, such as inadequately treated hepatitis associated with duodenal stasis due to functional disease of reflex origin, or obstructive from adhesions.

The basic causes of death are practically the same, whether patients die following appendicitis, pneumonia, compound frac-

tures, or stone in the common duct. Death is determined by the product of the damage done by preëxisting disease, the seriousness of the pathologic process encountered, the untoward effect of the treatment instituted, and lastly, failure to supplement the operative element of treatment with other measures which may and often will turn the tide of defeat. While surgery is an important factor in determining the outcome in a given case, it is far indeed from being the major element. The damage done by preëxisting disease may be totally beyond the scope of treatment, but the changes suffered by the heart, liver and kidneys, as well as the altered metabolism and body chemistry, must be reckoned with. These changes must strongly influence the plan of attack, whether the lesion is in the gall-bladder or common duct. This calls for scrupulous preparation of the patient for the ritual of the operating room.

Heart. Too often an examination of the heart consists in listening to the heart sounds, the recognition of murmurs if present, and a notation of the pulse rate. Some include an electrocardiogram, which does not invariably point out existing disease, while others place considerable reliance on the circulation time. Cardiac efficiency cannot, however, be estimated with the patient lying in bed. It is true many patients are unfit to be put through a test of cardiac action under effort, but those who can should certainly be checked to determine what the heart may do upon exertion. A surgical procedure, particularly in the upper abdomen, is often found to be an imposition too severe to be borne.

In biliary cases, in which demonstrable cardiac pathology is so often concurrent, it is important to determine the best procedure to lessen the risk as far as the management of the heart is concerned. Shall the patient be digitalized before or after operation? Is bed rest adequate preparation for upper abdominal operations, and what cardiac stimulation is of value if stimulation becomes necessary?

If these questions were settled in our minds a good step in the proper direction might have been taken. Certainly regardless of how we feel about these questions, the prime issue remains the accurate evaluation of cardiac efficiency as a factor in determining the limitations to be set for any surgical procedure undertaken.

The most valuable method of determining cardiac efficiency is by measuring the vital capacity. This factor is the truest criterion of myocardial function. It is lowered by (1) myocardial damage; (2) diminution in elasticity of lung parenchyma; (3) the presence of cardiac hypertrophy; (4) pericardial or pleural effusion encroaching upon the volume of the thoracic cage; (5) mediastinal lesions producing cardiac embarrassment; and (6) limitations of diaphragmatic excusion by subdiaphragmatic lesions producing pain or pressure.

Churchill and McNeill[1] state that "if it is realized that an operation involving the muscles of the abdominal wall temporarily leaves the patient with but 25 to 50 per cent of his preoperative vital capacity, it is readily understandable that a patient with an initial reading which approaches the tidal air requirement will be subjected to a grave risk by such a procedure."

Many prolonged procedures are done under unwisely chosen anesthesia, in inadequately and poorly equipped patients, who most likely would have survived had less surgery been done, or had regional or local anesthesia been employed. In chosen cases, survival is possible if the patient is given some opportunity and time to prepare the heart for the coming crisis.

Kidneys. Death of a patient on the fourth or fifth day after surgery is more often due to renal shutdown than to infection, especially in patients falling in the age groups of biliary disease subjects. One must shudder at the thought that in this day and age patients are still submitted to major surgical procedures with a urine analysis as the only index of kidney

function! Here again the surgeon is still too ready to ignore the value of the aid obtainable from a coöperating internist. Not enough preliminary estimations of the functional capacity of the kidneys are made. Thus, when considering blood chemistry preliminary to surgery, we are inclined to feel assured of a fair kidney function when we find urea nitrogen figures within what are called normal limits. A low blood urea, instead of indicating good elimination via the kidney, may point to a severe breakdown in liver function, since urea is synthesized in the liver. A low figure for blood urea can be of value only after the functional efficiency of the liver has been established in deamidizing proteins brought there from the intestinal tract via the portal vein.

Liver. In order to appreciate the relative importance of changes occurring in the liver, one must be acquainted with the functions now associated with that organ. One often hears that very little is known concerning the physiology of the liver. If, however, what is known about the liver were common knowledge, it would inevitably lead to a better understanding of the problems involved in the management of the pathologic states encountered. The term hepatitis means very little in terms of disturbed physiology, since a healthy looking liver at operation may be a very poorly functioning one, and vice versa.

In appraising the assets of a patient prior to surgical intervention, it may be very important to know certain facts about the functional status of the liver, e.g.: What is the capacity of the liver with regard to the regulation on the blood sugar level? Opie and Alford,[2] after extensive experimentation, have concluded that diet exerts a profound influence on the toxicity of certain substances which cause parenchymatous cell necrosis in liver and kidney. They have shown that susceptibility to liver and renal poisons is less after a diet rich in carbohydrates. Our gall-bladder patient can therefore be greatly aided by preoperative saturation of his liver with

glycogen. Insulin need not be used with intravenous glucose, since there is no evidence that insulin enhances the glycogen storage in the liver. Ravdin[3] gives all his liver cases 14 per cent of the total caloric requirements as proteins prior to operation in order to reduce the liver fat.

Following hepatectomy in dogs there is a progressive fall in the blood sugar level and the typical picture of increasing hypoglycemia develops. Coma and death follow. Intravenous glucose restores the sugar level and the normal appearance of the animal, but this restorative measure is of no value in previously pancreatectomized animals. Bollman, Mann and Magath[4] have pointed out that although the total amount of glycogen in the muscles is as great as, or greater than, that in the liver, muscle glycogen plays a very minor part in the regulation of the blood sugar. The dehepatized animal does not liberate muscle glycogen fast enough to prevent the early development of hypoglycemia. The glycogen storage in the muscles apparently is mainly reserved for muscular activity and the supply of sugar to the blood is almost entirely dependent on the functioning of the liver.

If the kidneys are removed at the same time as the liver, the blood urea remains constant at the level before operation, but amino acids accumulate in the blood, urine and tissues following hepatectomy. When amino acids are given intravenously or orally there is a rise of these substances in the blood and urine, but the values for urea remain unchanged. Uric acid also increases in the blood following hepatectomy. Hence the liver is necessary for the deamidization of amino acids, the synthesis of urea and the phases of destruction of uric acid in the metabolism of proteins and urea.

The liver also bears an important relation to the metabolism of the constituents of bile. Mann, Sheard and Bollman[5] have shown that bilirubinemia and bilirubinuria follow hepatectomy in dogs within three hours and that jaundice increases progres-

sively until the animals die. Using photo-spectroscopic methods, Mann and his associates found the pigment responsible for this jaundice was identical with bilirubin and that it is formed principally in the bone marrow and to a lesser extent in the spleen and the liver. In this respect therefore the liver is an excretory organ.

Human blood fibrinogen normally amounts to 0.27 Gm. per 100 c.c. of blood. It is markedly reduced in animals by liver damage, occlusion of hepatic vessels after hepatectomy and in cases of liver lesions produced by phosphorus poisoning and acute yellow atrophy.[6] Complete knowledge concerning the bleeding tendency of jaundiced patients is, however, still wanting. The maintainance of blood fibrinogen level by the liver has been studied by many investigators and it is generally agreed by them that the degree of liver damage necessary to produce a fall in the fibrinogen level is considerably greater than that met in simple obstructive jaundice.

Ravdin, Riegel and Morrison[7] feel that the hemorrhagic tendency of the patient or animal suffering from an obstruction of the common bile duct is not due to a deficiency of any known substance in the blood which normally takes part in the clotting mechanism. At present the general belief is that neither the bleeding time, the coagulation time, the blood calcium nor the fibrinogen content in the circulating blood offers any criterion for defining the bleeding tendency in jaundiced patients. Only one thing is true: that at present, with the exception of blood transfusion, carbohydrates by mouth or intravenously offer the best hope of preventing hemorrhage in patients with obstructive jaundice.

Since any or all the liver functions may be impaired to a degree, the appreciation of what is known to be going on will eliminate the element of surprise at postoperative complications. When disturbed function has been recognized, and as far as possible improved in the preoperative period, the surgeon is prepared for eventualities.

Many tests have been elaborated to help chart the assets of the patient about to be subjected to biliary surgery. Some of these tests are more valuable than others. The coagulation time, bleeding time and icterus index are of value only for determining the effectiveness of preoperative treatment. They require no amplification here.

The test of dye retention of Rowntree and Rosenthal is based on the knowledge that phenoltetrachlorphthalein is excreted solely by the liver, the disappearance of the dye from the blood being determined colorimetrically. Hence there is justification in guarding from surgery patients who fail to show a dye excretion incompatible with the risk of the operation planned.

The galactose tolerance test is of considerable value in determining the degree of liver damage. The interpretation given to it is applicable in cases where frequent blood chemistry determinations are not readily available. It has been pointed out that the elimination of 5 Gm. of reducing substance within five hours following the ingestion of the galactose very often is associated with an early death from hepatic insufficiency.

Operation. The operative technique in biliary surgery is perhaps the least determining factor. Everything else being equal, the writer is convinced that it matters little which of the various operative procedures are instituted as far as the ultimate result in a given case is concerned. Every surgeon will employ the procedure best suited in a given case after he has identified the nature and extent of the existing pathology.

Nevertheless, the ungratifying results of treatment both as regards mortality and morbidity, our failure to lower the death rate, as shown by figures for the United States Registration area, and our probable failure in checking the morbidity incidence, show that the immediate and remote results in biliary surgery are not too dependent upon the type of surgery done. Surgeons who are too pleased with their

results are very likely not following their patients long enough.

The problem of the stoneless gall-bladder is still begging for clarification. Since the gall-bladder is merely a diverticulum of a very extensive system of ducts, it appears that the patient in whom this organ is not functioning, should not be a candidate for its removal. Its lost function indicates that the patient has cholecystectomized himself. Why not consider that the body has thus cholecystectomized itself in self-defense, and eliminate the risk of death now too often following surgical cholecystectomy? The unwisdom of cholecystectomy in such cases is seen in the frequency of distressing functional disorders which follow the removal of a stoneless gall-bladder. This does not mean, however, that a gall-bladder which is a part of pathology in the right upper quadrant, and which produces tugging or other defects in the smooth function of the pylorus or duodenum, should be allowed to continue producing such disturbance.

In line with recently accumulated experimental and clinical data, it would appear that such cases of stoneless cholecystitis should not be subjected to cholecystectomy. These patients are suffering from hepatitis and pancreatitis, not from anything that results from the functionless gall-bladder. They should be treated medically by means of small frequent feedings of protein (preferably meats), fats and carbohydrates. The presence of food in the stomach and duodenum relaxes the sphincter of Oddi, thereby decompressing the extrahepatic ductal system. Meat has a great tendency also to rehabilitate the liver afflicted with chronic fatty infiltration, so prominent a feature in all biliary pathology. The fat in the diet, while it may in some cases produce symptoms of intolerance, is still necessary, inasmuch as it stimulates the flow of bile. Its stimulative action is less than that of meat, and it may be given in doses just short of producing the symptoms of fat intolerance. The administration of carbohydrates requires no further recommendation.

Cholecystograms. Since many conditions other than those which have their seat in the gall-bladder may be responsible for an x-ray diagnosis of a non-functioning gall-bladder, such a diagnosis must be interpreted in the line of newer knowledge. It has been shown that 40 per cent of all roentgenologically pathologic gall-bladders can, under treatment, be rendered roentgenologically functional. The value of x-ray diagnosis is subject to considerable limitations throughout. Yet is there any surgeon who has not operated upon a gall-bladder wherein he was tempted to interfere surgically, primarily because of the x-ray report? It seems that at present a fair evaluation of cholecystography must include an appreciation of its limitations and as a result its greatest value must lie in those cases where the roentgenologist finds biliary calculi.

CONCLUSIONS

Pre- and postoperative treatment is most effective in determining the results in any given case of biliary disease.

Liver pathology, inadequately appreciated before or at the time of operation, is largely responsible for unfavorable results.

Cholecystectomy, so far, is the better procedure in calculous cholecystitis.

Cholecystostomy, followed by a long drainage (eight to twelve weeks), will greatly lessen the unfavorable aftermath in cases of non-calculous cholecystitis associated with a definite hepatitis.

A number of patients who have undergone surgery for stone and who have had a scrupulous investigation of the common and extrahepatic ducts, will occasionally return with more stones; it must be concluded that stones in some cases at least, may form in the extrahepatic ducts rather than in the gall bladder.

Morphine administered to patients suffering from biliary colic is dangerous. While acting on the sensory cortex in the brain, it is nevertheless responsible for the production of a spasm of the sphincter of Oddi. This produces an increase of pressure in the extrahepatic ducts from a normal or

0–30 mm. of water to 300 mm. of water (McGowan, Butsch and Walters[8]). This is far above the capillary pressure—hence the damage to the liver lobule. Instead of morphine, nitroglycerine and erythrol tetranitrate have been employed by the writer with very gratifying results.

Once a diagnosis of biliary pathology is made, it is the surgeon's duty to have the patient's physiochemical assets in the best possible condition before undertaking operative procedures.

So far, the advocates of cholecystectomy for the acute gall-bladder have not proved their case. While some clinics report a low mortality in these cases, one shrinks from the fear that the practice might become generalized. Cholecystostomy in such cases is still a safer procedure, carrying with it a minimum of risk. It is becoming a greater favorite with many. Unfortunately the rank and file who practice cholecystectomy for acute cholecystitis do not oblige by publishing their figures, and from the observation of the writer there are extremely few clinics that can show a lower than 10 to 20 per cent mortality for the cases in question.

Employing physiologic and chemical data, the surgeon has a more thoroughly equipped armamentarium for the better management of biliary cases.

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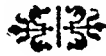
MANAGEMENT OF THE DESPERATE APPENDICITIS CASE*

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IF we are unreservedly to believe the statistics on appendicitis mortality we find that there has been a decided increase during the last thirty years. However, the statistics seem to be wholly unreliable because deaths due to appendicitis were formerly often not reported as such, but simply as peritonitis or intestinal obstruction. This is now no longer the case; the original appendicitis, listed as the cause of death, brings about an apparent increase in frequency.

The changing mode of living shows a definite tendency to increase the appendicitis incidence. A thorough statistical survey conducted in Germany covering the years of 1910 to 1929 shows that in a population of approximately 63,000,000 in 1910 there were 3,826 deaths from appendicitis in 48,996 cases. During the years of the war there was a gradual decrease of appendicitis deaths as well as a decrease in the number of appendicitis cases diagnosed. This was ascribed to more restricted diet and a more simple mode of living. By 1929 when the population of Germany was the same as in 1910 the deaths from appendicitis were 5,721 in 210,512 cases. The statistics also cover the frequency of appendicitis in the rural districts and in the cities, showing that the frequency in the cities is more than a hundred times greater. Evidently appendicitis is a disease of higher civilization, where occupations are more sedentary. The five-fold increase in frequency with only a twofold increase, or less, in the death rate illustrates the more efficient surgical treatment and perhaps the tendency to greater morbidity in a country with state medicine.

We may also blame the physicians. Many of us are altogether too willing to please the patient and apply the icebag or heat and adopt a watchful waiting attitude. We know that many cases of appendicitis subside, but should another member of the family or the same patient have another attack, the same treatment will be applied and the result may be an appendicitis which proceeds to perforation.

There is no doubt that an increase has occurred in the number of appendicitis cases which go on to gangrene and perforation, due to delay in seeking competent medical and surgical advice. In the Pacific Northwest, the prevalence of cults and faith healers is to a great extent to blame. This has forcefully been brought to my attention lately, as illustrated by the following two cases.

CASE I. A girl, 20 years old, was seized with vomiting and abdominal pain. She went to a chiropractor who treated her with, "spinal adjustments," and massage over the abdomen for days. A surgeon was called and diagnosed the case as ruptured appendix with an abscess, and a secondary rupture of the abscess into the peritoneal cavity.

CASE II. A man 30 years of age developed abdominal pain, had a chiropractic treatment the following day, and took cathartics. On the seventh day the abdominal pain became so severe that he could no longer bear it and he then summoned me. I found a bulging over the right lower quadrant and rigid abdominal muscles.

He was brought to the hospital and operated on, the incision being made over the abscess which was found to have ruptured into the abdominal cavity. The intestines were bathed in thin, whey-like pus. On the second day gas bacillus infection in the abdominal wall became apparent. Death resulted from toxemia produced by the gas bacillus infection.

In an editorial[1] in Surgery, Gynecology and Obstetrics, the statement is made that, "To operate in a case of spreading peritonitis invites catastrophe." The writer compares the condition with a skin or a subcutaneous progenic infection where the process is allowed to become localized and walled off before an incision is made for drainage. He states that the management of general peritonitis is identical.

It seems to me, however, that where we have a hollow viscus that becomes distended at the slightest provocation and especially when we have a peritonitis following a ruptured appendix, the thing to do is to relieve the distention and remove the cause if possible. It is important to reestablish the circulation as soon as possible, certainly before a paralytic ileus develops.

Gurd[2] states that, "the teaching, that the risk to the patient may be minimized by postponement of operation in the hope that a safe period may develop is to be condemned." My experience with a comparatively small series of cases leads me to believe that the postponement of the operation has very little in its favor. Draining an abscess and leaving the appendix in situ in selected cases is to be recommended. However, to do this as a routine will, I believe, cause an increase in the mortality rate and generally require reoperation. I have seen cases in which, years after drainage, appendiceal abscesses developed and caused death.

If nature has failed in its attempt to overcome the infection, if the appendix has ruptured, and abscess formation or spreading peritonitis or both have occurred, the best thing that can be done is for the surgeon to assist nature in its fight. From external examination it is almost impossible to tell the extent of the peritonitis. Everyone who has done any considerable abdominal surgery has made an incision in the upper abdomen or in the midline below the umbilicus, expecting to find the lesion there, only to find, to his surprise, an uninvolved peritoneal cavity in this location.

Instead there will be a ruptured appendix in the right lower quadrant. Many such cases, treated medically as generalized
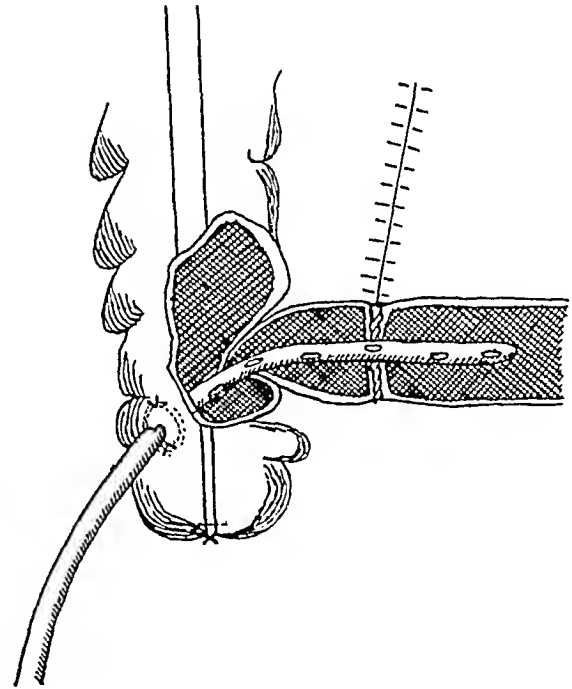
Fig. 1. Diagrammatic representation of the enterostomy tube in Case III. Where the tube is used for intestinal decompression in cases of gangrenous appendicitis with spreading peritonitis, the tube enters the cecum and ascending colon only.

peritonitis and reported as recovered, were in reality instances of circumscribed appendiceal abscesses, which may have ruptured into the cecum and drained themselves. There is only one way to treat appendicitis —early diagnosis and immediate operation.

In dealing with appendicitis which has developed into gangrene with peritonitis of varying extent, it is desirable to achieve a method of treatment which results in the smallest possible mortality and we feel that this is best done by aiding nature in its fight against the invading infection. In the abdominal cavity we find an easily distended viscus, whose distention cuts off the circulation to the intestinal wall by compression of its vessels. We can thus aid nature by deflating the viscus. The peritoneum has great power of withstanding and localizing any foreign invasion if there is no interference with circulation.

My method is to insert a No. 22 catheter through the appendix stump. If there is

much involvement at the base of the appendix, it is removed in the usual manner and another site on the cecum is used for the enterostomy. Where the appendix stump is being utilized, the catheter is fastened to it with a catgut suture. A purse-string suture is applied about the base of the appendix; it is invaginated around the catheter and the purse-string suture tied. A piece of omentum is placed about the catheter, and the latter is brought out through a stab wound lateral to the incision. The cecum may be anchored to the peritoneum. The enterostomy tube is fastened with silkworm gut to the skin. Adhesions which kink or bind down the bowel are released. Packs are used to protect the peritoneal cavity, if this can be done before the abscess is broken into. They are never put down through an infected area, since this merely helps to spread the infection. Abscesses are drained with gauze. Drains are never passed into an uninvolved portion of the peritoneal cavity, and they are never placed in the pelvis if pus is not found there at the time of the operation. Peritonitis travels by continuity.

The wound is closed in layers and the patient returned to the bed, where he is turned on his right side. The enterostomy tube is connected to a bottle, as in gall-bladder drainage.

I have always found this an effective means of keeping down the distention. The patient's postoperative course is much easier. There are no gas pains; the toxic intestinal contents are rapidly removed, and therefore there are fewer toxic manifestations. Since death in these cases is due to retroperitoneal infection and toxic absorption from the intestines, draining the intestines removes one factor. Administration of anaerobic antitoxin is also advisable.

The postoperative treatment of acute appendicitis with complications consists of constant attention to details. Daily rectal examination should be made. If abscesses develop, they should be drained through the rectum or, in women, through the posterior vaginal fornix. It is necessary to watch out for subhepatic or suphrenic abscesses. Nothing is to be given by mouth, but intravenous saline plus 5 per cent glucose should be administered as required, up to 3,000 c.c. a day. Subpectoral or hypodermoclysis may have to be used if the condition demands. No solution should be given per rectum and no enemas should be permitted. If there is gas in the distal portion of the colon, a rectal tube may be inserted. Constant heat to the abdomen, maintaining the patient in a semi-prone position to the right, and gastric lavage, if necessary, are valuable measures. Morphine may be given to avoid pain during the first few days. One must keep constant vigil to prevent complications from arising rather than to treat them after they have developed. The details of treatments should not be entrusted to nurses or interns if they have not been especially trained. The surgeon owes it to his patient to attend to the postoperative care himself.

CHART I

Number of cases	75
Age range	4 to 65 years
Duration before operation	9 hours to 7 days
Incidence of gangrene, peritonitis and abscess	56
Gangrene and peritonitis with no localization	17 (1 death)
Gangrene and peritonitis with subphrenic abscess	2
Miscellaneous	
Five months' pregnancy	1 (Smooth convalescence. Delivered at term of healthy baby.)
Gas bacillus infection	1 (Died)
Postoperative complications	
Subphrenic abscess	2
Pulmonary abscess	1
Perinephritic abscess	3
Pelvic abscess	7
Morality	2.6 per cent

Chart I shows the findings in the series of cases here presented. The mortality rate is low; perhaps in a greater number of cases it would be increased several times.

There is no doubt that many surgeons object to the method of treatment advocated. Many men are deathly afraid of fecal fistula—but a fecal fistula which is open to the outside adds nothing to the risk, and is definitely beneficial. The

operative time is not much lengthened by the enterostomy procedure, while the easier postoperative course makes it certainly worthwhile. No greater tendency to postoperative hernia is exhibited than in any other treatment with drainage. The fistula heals by itself, as a rule. (This has been true in all my cases. In one, a boy 9 years old, the closure took place in two months after the patient was home and again in good health.)

The enterostomy method is not new, but I am convinced that lives have been saved by it.

In this small group of cases (seventy-five), all have been operated on immediately, or as soon as possible, after the diagnosis has been made. There has been no delay or attempt to establish a safe period by Ochsner's method or any other procedure. Where the appendix had not ruptured, or where abscesses or spreading peritonitis were not present, enterostomy was not done and the cases were excluded. There have been two deaths in the series.

The following case (not included in the series) illustrates the advantage of enterostomy and the ease with which it closes when properly performed. The acutely inflamed appendix in this case required no enterostomy, but there was obstruction with mesenteric thrombosis. The smooth and short convalescence in this serious case I attribute to the enterostomy.

CASE III.   A female, age 50, five years before had had what was supposed to have been an abscessed appendix which was drained. Her present illness began three days before admission with intermittent pain in the abdomen, which had gradually become worse. There had been no bowel movements for two days.

On examination, I found a moderately distended abdomen with visible peristalsis. There was a ventral hernia following the right rectus incision at the previous operation. The contents of the hernial sac could easily be reduced, but this did not affect the symptoms. The temperature was 100 and the pulse 90. My diagnosis was an obstructed bowel due to adhesions.

The patient was brought to the hospital and an incision was made just medial to the old scar. About 3 feet of the terminal ileum were found to be discolored, edematous and caught in a tight band. The mesenteric veins to the same portion were thrombotic. The last few inches of the ileum were not involved. The appendix was free, but acutely inflamed. There were no signs of any previous involvement about the appendix. We did a resection of the ileum together with the mesentery containing the thrombotic veins. An end-to-end anastomosis was made to the terminal portion of the ileum and the appendix was removed. A No. 22 catheter was inserted through an enterostomy in the cecum, through the ileocecal valve, and past the anastomosis. The hernia was repaired.

The patient made an uneventful recovery without distention or discomfort. The enterostomy tube was removed on the fifth day and the fistula was healed on the eighth. The patient left the hospital in two weeks and has remained well since.

SUMMARY

1. The frequency of appendicitis is increasing with advance in civilization.

2. Delay in seeking competent aid is the main factor in the mortality rate and medical treatment shares a portion of this responsibility.

3. The influence of cultism in the Northwest is also a factor.

4. Operative interference is recommended at time of diagnosis irrespective of the condition of the patient.

5. Removal of the appendix is necessary, with an enterostomy at the primary operation and drainage with gauze of the abscess cavities.

6. Antitoxin for anaerobic infection is administered in cases of ruptured appendix.

7. The right lateral position is best for drainage.

8. Careful postoperative management is advised, with the surgeon taking personal charge and making daily examinations.

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PRIMARY CARCINOMA OF THE LIVER*

REPORT OF A CASE AND REVIEW OF THE LITERATURE

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PRIMARY carcinoma of the liver is comparatively rare, and a great deal that has been written on the subject is scattered among the pathologic and medical journals. However, the subject is by no means out of the realm of the surgeon. He encounters it during an exploratory laparotomy, only to find the peritoneal cavity full of blood from an eroded malignant nodule, or during an exploratory operation for an abdominal tumor of unknown origin. He is also confronted with it during an operation for "empyema of the gall-bladder," and sometimes a "gastric tumor" will turn out to be a primary tumor of the liver.

In order to study the prevalence of primary carcinoma of the liver, the autopsy records of thirty-one institutions of various countries were studied. The total number of autopsies collected was 159,762 (representing all deaths that came to autopsy). Of these, 808 were proved to be primary carcinoma of the liver, giving a percentage of 0.506. (Table I.) To the 808 cases are added 153 cases of primary carcinoma of the liver collected from the literature (Table II), where the ratio to the total number of autopsies was not given, and also 164 cases originally reported by Eggel in 1901, making a total of 1,125 cases of primary carcinoma of the liver reported in the literature up to August 1937. The ratio of primary carcinoma of the liver to all other malignancies is given as 8.4 per cent by Brines and 17 per cent by L. W. Smith (Philippine Islands), and 1.5 to 3 per cent by Jaffe. Of 3,300 malignant cases that came to necropsy at the Middlesex Hospital, as reported by Callwell, 41, or 1.2 per cent of all malignant diseases, were

primary carcinoma of the liver. The proportion of primary to secondary carcinoma of the liver is given as 1 to 21 by Hale White, 1 to 64.5 by Orth, and 1 to 40 by Hansemann.

Primary carcinoma of the liver is more common in males than in females. In Eggel's series of 164 cases, 63.3 per cent occurred in males. The age incidence is the same as in any other malignancy. It is found at all ages. It may occur in infancy or childhood, but is most common after the age of forty. Muller reported a case of primary carcinoma of the liver in a man of 83. Griffith recorded fifty-seven cases under the age of 16. Dansie collected twenty-five cases under 2½. Although cancer in general is less common among colored races, primary carcinoma of the liver is more prevalent among them. Strong and Pitts reported twelve cases from the Vancouver General Hospital, ten of which occurred in Chinese. Tull reported 134 cases from the pathologic clinics of Singapore; 126 occurred in Chinese. Kika, in 1929, reported 110 cases of primary carcinoma of the liver from the Pathologic Institute of Tokio, and collected from the Japanese literature 223 cases since 1915. Von Hansemann examined 200,000 natives of the German colonies in Africa and found only twenty-one cases of all forms of cancer; four of these were primary carcinoma of the liver.

Pirie found ninety-six cases of all forms of cancer in South Africa, of which thirty-six were primary carcinoma of the liver. He attributed the disease to the prevalence of schistosomiasis among the natives. The parasite was found in 10 of the 36 cases. Pitts states that almost 100 per cent of the

TABLE I

RATIO OF PRIMARY CARCINOMA OF LIVER TO TOTAL NUMBER OF DEATHS THAT CAME TO AUTOPSY

Source	Number of Autopsies	Cases of Primary Carcinoma of Liver	Percentage
Barry and Russum. Creighton University School of Medicine	1,100	4	0.363
L. W. Smith. Philippines General Hospital	872	12	1.376
Berglund	1,312	16	1.219
Strong and Pitts. Vancouver General Hospital (1920–1931)	1,967	12	0.61
Goldzieher and Bokay. Path. Inst., Budapest	6,000	18	0.3
W. Hale White. Guys Hospital, London	18,500	24	0.129
Kika. Path. Inst. Tokio Univ., Japan	11,494	110	0.965
K. Smith. Cook County Hospital	4,044	25	0.618
Tull. Tan Tock Seng. Hospital, Singapore	17,664	134	0.758
Brines. Detroit Receiving Hospital (1929–1932)	1,087	8	0.736
Clawson and Cabot. Univ. Minnesota	5,100	1	0.019
Winternitz. Johns Hopkins Hospital	3,700	3	0.081
Wheeler. Guys Hospital, London	5,233	15	0.287
Von Glahn and Lamb. Presbyterian Hospital, New York	1,800	6	0.333
Rowen and Mollary. Boston City Hospital	6,506	9	0.138
Counseller and McIndoe. Mayo Clinic	5,976	5	0.083
Fried. Peter Bent Bingham Hospital	1,200	4	0.333
Fox and Bartels. State University of Iowa	1,500	2	0.133
Orth	258	4	1.55
Wilson. Roger Hospital, Charleston	818	2	0.244
Pirie. South African Inst. for Med. Research	91	36	39.56
Hansemann. Berlin Path. Inst. (1870–1889)	258	4	1.55
Chao-Jen Wu and Hsi-Jung Kang. Peiping Union Med. College	856	3	0.35
H. Collwell. Middlesex Hospital	12,500	41	0.328
H. Hill Univ. of Texas	150	3	2.0
Ciceri, Corso. Venice Hospital (1911–1931)	19,000	124	0.652

TABLE I (Continued)

Source	Number of Autopsies	Cases of Primary Carcinoma of Liver	Percentage
Cantele, P. G. City Hospital, Venice (1906–1929)	19,008	44	0.231
Yomone, M. Japan	2,503	57	2.277
Glynn, E. Liverpool Royal Infirmary (1922–1935)	2,050	16	0.78
Redaelli, P. Inst. Path. Anatomy, Univ. of Pavia	5,050	48	0.95
Hudimaki, Shigeo. Path. Inst., Niigata, Japan (1911–1935)	2,165	18	0.831
Grand totals	159,762	808	0.506

population in Kwantung (Southern China) are infected with intestinal parasites, the common fluke. Ascoli found that all his cases gave a history of syphilis, malaria or alcoholism.

Primary carcinoma of the liver occurs anatomically in three forms: the nodular, consisting of various circumscribed tumor nodules; the massive, composed of a large single tumor invading one of the lobes; and the diffuse, where the tumor process invades the whole liver substance. Histologically, they occur either as cholangiomas involving the intrahepatic bile ducts, or hepatomas arising from the parenchymatous liver cells. Hepatomas are most common and are most frequent in males. It is also known that cirrhosis of the liver is predominantly found in males. Cholangioma is most prevalent in females, perhaps due to the fact that bile duct infection is more common among females. Early vascular invasion of the intrahepatic blood vessels is a striking characteristic in hepatomas. Extrahepatic matastasis is most frequent in cholangiomas. Both may be associated with hypoglycemia or hemochromatosis. Jaffe reported a case of sarcoma and carcinoma of the liver in the same patient.

TABLE II

LIST OF CASES OF PRIMARY CARCINOMA OF THE LIVER REPORTED IN THE LITERATURE (NOT INCLUDED IN TABLE I)

Author	No. of Cases	Author	No. of Cases
Boyce and McFetridge..	28	Hicks	1
Glynn..	16	Huguenin............	1
Ulman and Loesch.....	10	Hustin..............	1
Karsner.............	9	Jackson.............	1
Hess................	8	Jano and Matsuoka...	1
Blumenau............	7	Johnson and Hall....	1
Ascoli..............	6	Karajanopoulos	1
Montanari...........	5	Koster and Kasman...	1
Hill...	4	LeGrand............	1
Rugers	2	Liesch.............	1
Wilson..............	2	Margarot, Rimbaud	
Abel................	1	and Guibert.......	1
Banet and Bolanas...	1	Marono and Galand..	1
Barre and Paillas	1	Martinez...........	1
Beers and Morton.....	1	Mast and Streamer...	1
Benoit..............	1	Moon..............	1
Blina...............	1	Montpellier and Loub-	
Bolker, Jacobi and		eyre..............	1
Koven.............	1	Müller.............	1
Bosq and Pucher.....	1	Nadler and Waifer...	1
Briggs..	1	Neuffer............	1
Brodin, Bolgert and		Orr................	1
Placa.............	1	Pallasse and Rougier..	1
Cabot..............	1	Paviot, Martin, Gur-	
Calcagni............	1	chard and Girard...	1
Callerio............	1	Peasley............	1
Catsaras............	1	Plazy, Mondon and	
Crawford...........	1	Berge.............	1
Ehrlich and Ansanelli...	1	Prym..............	1
Elliott.............	1	Rosenthal..........	1
Finkelstein and Jacobi..	1	Schlomoritz and Glick-	
Finny and MacFarlane..	1	man..............	1
Gay................	1	Schnabel...........	1
Geschickter and Cope-		Solowej............	1
land..............	1	Surbek and Vos......	1
Goldberg and Waller-		Thomson...........	1
stein..............	1	Trimarco and Behr....	1
Hedrick............	1	Willis..............	1
	120		34
Total..............	...	....	153

That cirrhosis of the liver plays an important part and is a predisposing factor in the formation of primary carcinoma of the liver is agreed by practically every writer on the subject. It is found in from 85 to 100 per cent of hepatomas and in 50 per cent of cholangiomas (Yamagiwa). Counseller and McIndoe questioned the diagnosis of primary carcinoma of the liver in the absence of definite cirrhosis. Blumenau made a study of 198 cases that died from cirrhosis. He found that 3.5 per cent of the series had primary carcinoma of the liver. Fried believes that cirrhosis is a reparative process in response to injury followed by hypertrophy and hyperplasia of liver cells, which gives rise to the forma-

tion of multiple adenomatous nodules which may eventually become malignant. Glynn describes a case where he found all three factors, hyperplasia, adenoma, and cancer in the same specimen. Muir states that the association of cirrhosis with cancer is much too frequent to be a mere coincidence. He agrees with Orth that the vicarious proliferative process for some unknown reason oversteps the normal and takes on the autonomous character of a new growth. That liver tissue has great powers of proliferation was proved experimentally by Podwyssowski and Mann. The latter removed 70 per cent of the liver in animals, and this was followed by practically complete regeneration in the course of a few months.

Cirrhosis in itself may be secondary to syphilis, alcoholism, malaria, parasitic and infectious diseases. Of the sixteen cases reported by Glynn, five had biliary calculi. Cases have been reported by Hicks, Crawford and Calcagni that gave a history of direct trauma before the appearance of the symptoms.

Intrahepatic metastasis is quite frequent. The intrahepatic veins are almost always involved, forming small thrombi which may extend to the larger veins and inferior vena cava and right auricle, as shown in the cases of Winternitz, Counsellor and McIndoe, and Barry and Russum.

In spite of early vascular involvement, extrahepatic metastasis is not frequent. When it does occur, it is most common in the lungs, mediastinum and upper abdominal lymph glands. Twenty per cent of all primary carcinomata of the liver metastasize to the lungs. Metastasis into the sac of an inguinal hernia was reported by R. A. Willis. Jano and Matsuoka reported a patient who died from cardiac failure caused by hydropericardium and ascites. Autopsy revealed a primary bile duct carcinoma of the liver, with massive pericardial effusion from multiple cardiac metastases. Peasley reported a case of primary carcinoma of the liver with invasion of the portal and hepatic veins and

gangrene of the small intestine. Bolker, Jacobi and Koven in 1937 collected from the literature nine cases of primary car-

to enable one to make a positive diagnosis. In the early stage, the patient will complain of vague gastrointestinal disturbance,
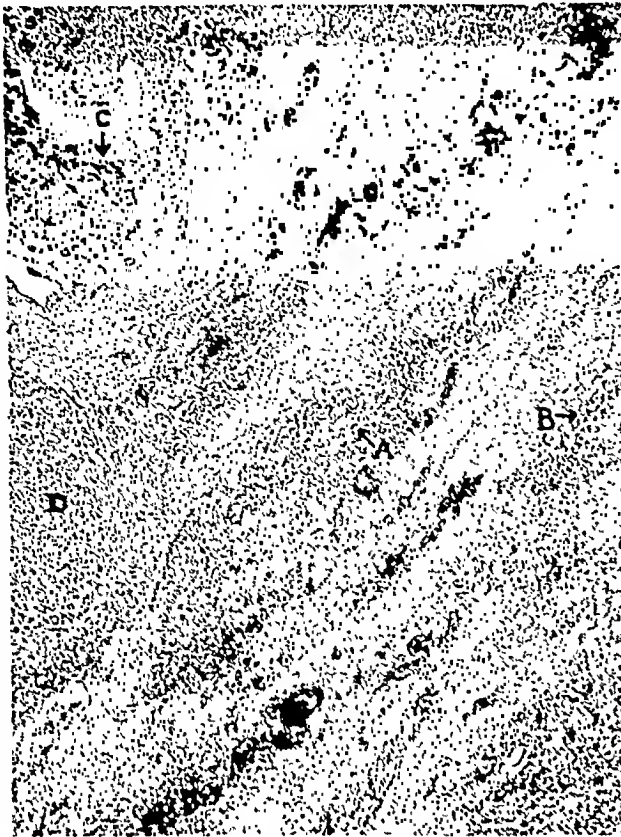
FIG. 1. Low power magnification of a representative section of liver. A, persisting cords of normal liver cells spread apart by edema. B, a nest of regenerating liver cells surrounded by scar. C, regenerating liver cells merging indefinitely with neoplastic masses. D, a mass of malignant liver cells occupying the lumen of a periportal blood vessel.

FIG. 2. High power magnification through a characteristic area of the hepatoma. A, the mass of malignant liver cells, including giant cells growing into B, the lumen of a blood vessel. C, the dense scarring of periportal areas accompanied by round cell infiltration. D, a nest of malignant cells adjacent to and occupying portion of the vessel wall.

cinoma of the liver with skeletal metastis and reported one of their own. To these are added the three cases of K. J. Smith, one of Counsellor and McIndoe, two of Surbek and Vos, one of Thomson, and one of Hedrick, making a total of eighteen cases of primary carcinoma of the liver with skeletal metastasis, or 1.6 per cent of the total number of cases of primary carcinoma of the liver reported in the literature up to the present writing. The comparative freedom from metastasis in spite of early thrombosis may be due to the short duration of the disease. The patient is dead before distant metastasis takes place.

There are no pathognomonic symptoms or signs in primary carcinoma of the liver

nausea, sometimes diarrhea, anorexia and weakness, and later progressive loss of weight. He then develops signs and symptoms of atrophic cirrhosis. The abdomen becomes distended, the superficial abdominal veins are engorged. Ascites develops in about 58 per cent of cases, jaundice in 61 per cent, with edema, especially of lower extremities in 41 per cent (Eggel's statistics). When an abdominal paracentesis is done, the liver is seen and felt below the costal margin, sometimes as low as the umbilicus. The characteristic of liver enlargement, however, is upward into the thorax, as seen by roentgenogram examination of the chest and on percussion. Mallory's patient (#22051) had an explora-

tory operation of the right chest for a mediastinal tumor and it was discovered that the tumor was a primary hepatoma pushing the diaphragm high into the chest cavity. Of 134 cases reported by Tull, in fifty-two the dome of the liver was pushed up into the thorax, sometimes as high as the third rib. Pain and dyspnea depend on the pressure of the tumor mass upon the adjacent structures.

Diagnosis is often missed even after exploratory operation and the taking of a biopsy. The biopsy will be reported as cirrhosis, and so it is, but the patient has associated with the cirrhosis primary carcinoma of the liver. Various liver function tests are of no avail in carcinoma, for many other liver diseases will give the same results. Few of the cases reported have been diagnosed clinically. The records of the past have been based on necropsy findings and on operative removal of a malignant tumor after surgical exploration.

The treatment of primary carcinoma of the liver is exclusively surgical. There is no other choice of treatment. This is one type of malignancy which is out of the realm of radiology. When one takes into consideration that the duration of life after the appearance of the tumor is about three months, the mortality following operation, even when very high, is not of such great consequence as in other types of less fatal malignant disease. It is generally agreed that every case of primary carcinoma of the liver should be explored, but this should be done not only for diagnostic purposes and the taking of a biopsy, but also with the idea of a possible excision of a solitary malignant tumor or even a lobectomy. The fact that the blood supply of each lobe is practically distinct and the amount of connective tissue very abundant, bespeaks its safety. Wright states, "I think that the simple method of cutting boldly through the liver tissue is quite safe."

In reporting a case of resection of the left lobe of the liver for primary carcinoma, Keen in 1899 collected from the literature seventy-six cases of resection of the liver for hepatic tumors. Sixty-three recovered, eleven died, and the termination of two was uncertain, giving a mortality of 14.9 per cent. Keen asked, "If we cure 50 per cent of cases of cancer of the breast and over 50 per cent of cases of cancer of the rectum and uterus, why should we not get equally good results at least in these cases of cancer of the liver which are well limited and with little or no lymphatic involvement?" He concluded that every case, saving those manifestly beyond relief, should therefore be explored and the later steps be determined by what is found. Thomson notes with surprise that in his collection of forty-seven cases from the literature of neoplasms of the liver that have been operated on, only two died from hemorrhage, and in the forty-seven cases there were only six deaths.

Yeoman in 1915 reported a case of primary carcinoma of the liver in which he operated for recurrence over seven years after the primary operation. He collected from the literature fifteen other cases of primary carcinoma of the liver in which there had been operations. Of these, four died from various causes within sixteen days after operation, six had a recurrence in from two months to eight years after operation, and six were alive and well from three to seven years after operation. He concludes that the only hope for improvement in results lies in the direction of earlier operative exploration in patients with tumors in the right upper quadrant in whom no primary growth can be found.

Table III shows fourteen additional cases of malignant tumor of the liver operated on since the reports of Keen, Thomson and Yeoman. (Hemangiomas, gumma and cystic tumors of the liver are omitted.)

REPORT OF CASE

A 30 year old Philippine male was admitted to Cumberland Hospital on March 31, 1935 complaining of intermittent sharp, shooting pain in the right upper quadrant, right chest, shoulder and axilla, and soreness in the epigastric region of four weeks' duration. The pain was relieved on deep respiration.

TABLE III

SUMMARY OF FOURTEEN CASES OF CARCINOMA OF THE LIVER WHERE OPERATION ON THE LIVER WAS PERFORMED

Sex and Age	Pathology	Operative Findings	Method of Removal	Results	Author
Male 13	Tumor weight 2 lbs. 3 oz. Hepatic adenoma.	Lobulated tumor occupying almost one half of right lobe of liver. No other organs involved.	V-shaped incision, apex at cystic duct. Gall-bladder removed with tumor after ligating cystic duct and vessels. Stomach clamp, knife and scissors, long intestinal needle and chromic No. 3 used. Edges approximated.	Excellent health one year and ten months after operation. Working.	Turner, Grey
Male 60	Tumor partially encapsulated. Liver cell carcinoma.	Tumor size of orange in right lobe of liver. Thought to be primary carcinoma.	Tumor shelled out after removing gall-bladder. Bleeding controlled by pressure and swab. Vessels clamped and ligated. Wound packed with gauze.	Well three years after operation.	Wright, G.
Female 40	Carcinoma.	Carcinoma of gall bladder, stones, malignant module of liver.	Excision by scalpel of wedge of liver with gall-bladder, measuring 3 × 3½ × 2 inches. Bleeding controlled by digital pressure and gauze. Gap filled with omentum. Sutures passed through omentum and liver. Omentum later detached from main omental sheath.	Well after fifteen months. Could not be traced later.	Frankau, C.
Female 29	Adenoma of the liver.	Peritoneal cavity full of blood. Pelvic organs normal. Large cone-shaped tumor at inferior surface of right lobe of liver. Rent 3 inches in tumor from which blood was escaping. First thought to be ectopic pregnancy.	Tumor removed by cautery.	Died one hour after operation.	Turner, P.
Female 57	Adenoma of the liver.	Preoperative diagnosis subacute appendicitis. Tumor size of cricket ball in right lobe of liver.	Splinting sutures. Wedge-shaped area removed with tumor.	Patient did well but died from "heat stroke."	Kidd, F.
Female 54	Carcinoma of adrenal rest.	Yellowish tumor of lingual lobe of liver.	Clamped, resected, mattress sutures applied.	Lived two years after operation.	Nitch, C. A. R.
Female 80	....	Tumor occupying almost the entire left lobe of liver, measuring 16 × 12 × 12 cm.	Tumor resected after left hepatic artery and vein ligated.	Patient in good health seventeen months later.	Jackson, R. H.

TABLE III (*Continued*)

Sex and Age	Pathology	Operative Findings	Method of Removal	Results	Author
Male 35	Primary carcinoma of liver.	Two tumors size of grapefruit at under surface of left lobe by pedicle. No other involvement.	Clamped, cut, sutured.	Well eleven months later. Gained 22 lbs.	Goldberg, Wallerstein.
Male 51	Cholangioma. Tumor 8½ × 6½ × 4 in. 3 lbs. 11 oz.	Large tumor at left lobe of liver.	Practically the whole lobe was removed. Series chromic No. 2 sutures passed through whole substance of liver and tied. Tumor with 1 inch of normal tissue removed. Practically the whole left lobe of liver removed.	In good health seven months after operation.	Abel, A. L.
Male 43	Encapsulated tumor with central degeneration. 9 × 8 × 7 cm. Primary carcinoma.	Encapsulated tumor left lobe of liver, size of orange. Embedded in a "band of cirrhosis" 2 inches wide.	Excised by sharp dissection. Cut surface sewn as cut with interlocking double catgut.	Died six months after operation.	Hicks, E. S.
Male 59	Hepatoma. Autopsy findings metastasis to right lobe, peritoneum, heart.	Large tumor involving the left lobe. No other foci.	Partial resection of left lobe, portal vein and hepatic artery clamped and tied. Remainder of left lobe removed by electric cautery.	Died six weeks after operation.	Love
Male 51	Adenocarcinoma of the liver.	Large cystic tumor involving left lobe of liver, filled with blood clots and macerated liver tissue.	Tumor resected, blood vessels clamped and tied. Cut surface of liver approximated with catgut.	Patient in good health nine months after operation.	Hustin, A.
Male 43	Primary carcinoma of the liver.	Malignant nodule at free border of liver. All other organs normal.	Malignant nodule, gallbladder with wide margin of normal tissue excised.	. . . .	Le Grand
Female 44	Tumor weight 940 Gm. Adenocarcinoma.	Large tumor involving most of right lobe of liver.	Excision.	Alive nine years after operation.	Wendel, W.

Two years previous he was admitted to a hospital for "stomach trouble" and had a gastrointestinal series done. As the series was negative, he was discharged. Ever since, fried foods, meats and fats gave him a great deal of flatulence, nausea, and pain in the epigastric region. He had gonorrhea in 1925, but otherwise he had never been sick. He had an occasional cough with no expectoration and no hemoptysis, and also a slight orthopnea. He

used to drink a large quantity of alcoholic beverages until two years previous, when he had developed "stomach trouble." His family history was essentially negative.

Examination revealed a 30 year old Philippine male, moderately nourished, not acutely ill, comfortable. His temperature was 101°F., pulse 80, respiration 24, blood pressure 124/72. The head and neck did not reveal any abnormality. The chest showed signs of dul-

ness and flatness over the right base with suppressed breath sounds and occasional râles. There was no evidence of any abnormality of the heart.

The abdomen was asymmetrical and slightly distended, with a moderate amount of edema of the skin. The superficial abdominal veins were engorged. The right upper quadrant was very prominent. The upper border of liver dulness extended to the fourth interspace. The liver edge was palpated three fingers below the costal margin (very tender), while the left lobe extended to the left costal margin. The spleen was not palpable nor were any other masses palpable. There was a 2 plus edema of both ankles and the lower third of the legs.

The urine showed a slight trace of albumin with no bile present. The blood Wassermann was negative. A blood chemistry indicated 15 mg. urea nitrogen, 1.7 mg. creatinine, 3 mg. of uric acid, and 80 mg. of sugar. There were 8,750 white cells with 77 per cent polymorphonuclear leucocytes and 28 per cent lymphocytes; the hemoglobin was 60 per cent. The icteric index was 6.1; the Van den Bergh test was negative. The stool examination was positive only for blood, and contained only Bacillus coli. The Takata-Ora test was positive. The gastric analysis was normal. A flat plate of the abdomen showed the lower border of the liver about 6 cm. above the intercostal line. Roentgenogram of the lungs showed no infiltration or consolidation. Sedimentation time was 35 minutes.

On April 22 the abdomen became more distended and slightly rigid, while a cystic mass was felt over the right lobe of the liver. The patient did not do so well. On April 24 an exploratory laparotomy was performed by Dr. Merrill N. Foote. Upon the opening of the peritoneum, the abdomen was found filled with blood, blood clots, and hemorrhagic ascitic fluid. The superior and inferior surfaces of the liver were covered with circumscribed bluish areas simulating localized hemangiomas. The bleeding came apparently from the superior surface of the liver and could not be exposed. The liver surface was packed with iodoform gauze after removal of the clots and removal of the fluid by suction. A biopsy was taken from the anterior border of the liver and the edges were approximated with chromic No. 2. The abdomen was then closed in the usual manner. The patient did not do so well after the oper-

ation, but improved after stimulants and a transfusion of 500 c.c. of blood. However, two days later, on April 26, he died. As the biopsy from the liver was reported as cirrhosis, he was signed out with that diagnosis.

Autopsy performed by Dr. S. H. Polayes disclosed that the peritoneal cavity contained about 2,000 c.c. of blood and several large clots in the right gutter. The omentum was adherent to the superior surface of the right lobe of the liver. On removing the omentum from that area, a degenerated, necrotic, "abscess-like" cavity was disclosed, measuring about 5 cm. in diameter, containing necrotic slough. The omentum partially sealed this cavity. The liver was tremendously enlarged, weighing more than 3,200 Gm. The entire right lobe appeared necrotic and hemorrhagic. On section through the abscess-like area, the tissue appeared cystic, containing dark, chocolate, reddish colored fluid of purulent consistency. The area immediately surrounding the mass was red, soft, and necrotic, involving a large part of the right lobe. The left lobe contained fairly normal liver structure with areas of fat replacement.

On microscopic examination, the more normal portion of the liver showed evidence of destruction of the hepatic lobules, increase in the number of bile capillaries, replacement of liver cells by connective tissue and evidence of regeneration of liver cells. The section of the right lobe of the liver which was the seat of the neoplastic involvement showed large areas of necrosis, cystic degeneration, and hemorrhage. There were large numbers of nests of neoplastic liver cells among which were numerous giant cells with nuclei undergoing mitosis. There was complete absence of normal liver tissue.

Glisson's capsule was the seat of an inflammatory process with round cell infiltration. The rest of the abdominal viscera showed no evidence of pathology.

The visceral and parietal pleura were densely adherent to each other and the adhesions were separated with difficulty. On section the right lung showed lobular patches and pneumatic consolidation. Histologic examination revealed the presence of miliary tubercles and areas of lobular pneumonia.

The final diagnosis was hepatoma, miliary tuberculosis of the lungs, lobular pneumonia, pleural fibrosis, peritoneal hemorrhage, aortic atherosclerosis.

SUMMARY

1. Primary carcinoma of the liver is comparatively rare.

2. There is very little written on this subject in the surgical literature.

3. An exhaustive review of the literature on the subject was made, and 1,125 cases were found to have been reported.

4. The pathology and the clinical course of the disease are discussed.

5. A plea for more surgical interference in primary carcinoma of the liver is made, through the medium of men in the past who are more qualified to speak on the subject.

6. A table is included containing a summary of fourteen cases that have been operated on for primary carcinoma of the liver.

7. An additional case of primary carcinoma of the liver complicated by miliary tuberculosis is reported.

8. References are included, comprising practically everything that has been written on the subject.

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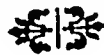
THE MANAGEMENT OF CHRONIC OCCLUSIVE PERIPHERAL ARTERIAL DISEASE

IMPRESSIONS GAINED FROM SIX YEARS OF CLINICAL STUDY

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CHRONIC occlusive arterial disease unfortunately is widespread among the adult populace. Its progression is attended with dire results; its complications are often serious, not infrequently fatal. Too often the practitioner is unmindful of the seriousness of the affection, and at times even of its nature.

Every patient with complaints referable to the peripheral arteries should have a thorough physical examination. The presence or absence of diabetes must be definitely established. The peripheral circulation should then be carefully studied by one fully versed in the anatomy and physiology of the peripheral vessels. The part played by the autonomic nervous system should be determined by a quantitative measurement of the degree of vasoconstriction, using an accepted method of vasomotor study. The writer prefers peripheral nerve conduction block as the most reliable method of inducing vasoconstrictor paralysis. His experiences with this method will be reported in an article to follow. One cannot expect the general practitioner to be versed in the details of a thorough vascular study; but his lack of training in this respect is no excuse for denying this to the patient when a vascular surgeon is within reach.

The chronic arterial occlusion may be due to arteriosclerosis, thrombo-angiitis obliterans, endarteritis obliterans, or other more rare affections. Irrespective of etiology, the important manifestations are the result of diminished blood flow. In each group, the goal in treatment is to increase the available circulation to the affected limb. There are at present no well recognized specific means of treatment of the various types of occlusive arterial disease. To a great extent, rational treatment depends on the results of the vasomotor study.

If there is little or no vasoconstrictor element, the use of drugs or other means directed towards the decrease of sympathetic influence is not indicated. Suction pressure therapy has been strongly advised by others for this group. The writer has had experience with approximately 5,000 hours of suction pressure treatment. Most of the cases were proved by vasomotor studies to have little or no element of vasoconstriction. A few patients have reported worthwhile results, some only temporary; in the majority, however, the results have been most disappointing. The use of intravenous hypertonic salt solution, adrenalin-free pancreatic extract, padutin, and other drugs, has met with little success in the author's hands in relieving symptoms or altering the course of the disease.

Gratifying results have been obtained in a small series of patients treated by ligation of the main vein to the extremity. Patients for vein ligation must be carefully selected; they should have little or no element of vasoconstriction and should show only mild evidence of circulatory incompetency. Following vein ligation the surface temperature of the extremity has shown a persistent increase, and both symptoms and objective findings have shown improvement. However, it is useless to attempt this procedure in advanced cases of arterial disease.

Circulatory postural exercises as advised by Buerger and carried out systematically

for three hours daily are of distinct benefit. The writer has had no experience with intermittent venous compression as recently advised by Collens and Wilensky. Strict daily hygiene of the feet must be a part of the management of every case. The skin must be kept soft, clean, and free of trauma. If the skin is broken, care must be exercised to keep the lesions aseptic, with the scrupulous avoidance of strong antiseptics such as tincture of iodine.

Most cases of ulceration or gangrene due to arterial disease show little or no vasoconstriction. Certain points in the treatment of these cases are worthy of mention. The involved extremity should not be elevated as a routine—I have no doubt that many extremities are sacrificed because this antiquated outworn dictum is rigidly followed. The extremity should be kept at its optimum level, obtained by elevating the extremity for a few minutes until it blanches and then slowly lowering it until the normal pink color is present. The patient usually feels more comfortable at this point. In most cases the optimum level is slightly lower than the horizontal. If there is a suppurative lesion, its site should hang dependent to promote drainage, even if this requires placing the patient in the supine position.

The extremity should be kept warm, but great care must be exercised in the use of electric lights or appliances. I have seen extremities sacrificed and even death result from burns produced by electric heating devices, so that I no longer countenance the use of electricity for this purpose. The methods of heating must be absolutely fool-proof. The degree of heat must not be gauged by the sensations of the patients, for his extremity may be anesthetic or hypesthetic. No form of heat should be applied unless a sensory examination has been previously made.

The extremities must be so placed that there are no areas of pressure; the heels must be kept scrupulously away from the mattress, and the patient's bed should be fitted with a Balkan frame with a hand

trapeze, so that he can move himself without using his heels. The cradle which covers the extremities should be thoroughly padded to prevent mechanical injury. Constant vigilance by the physician himself is necessary to prevent calamities occuring during the course of treatment. To be suddenly aware that due to pressure a gangrenous spot has appeared on the heel of the less involved extremity is often evidence of neglect, and most embarrassing. One must not be so eager to treat the obvious lesion that his attention is withheld from the danger of such complications in the "good" but often poorly nourished fellow opposite.

In those cases where the occlusive disease is accompanied by a marked or considerable element of vasoconstriction, best results are obtained by releasing this factor. In the author's experience, the use of vasodilatory drugs, by mouth, injection, or iontophoresis; contrast or cold baths, diathermy to the sympathetic chains or the affected extremities, or vaccine fever have not been promising.

Sympathetic ganglionectomy will produce an increased circulation to the affected extremities, at least to the extent indicated by the vasomotor studies; and this increase will persist at the maximum test level or slightly below it for an extended period. The increased blood flow is present continuously, day and night, and is more marked and more persistent than that obtained by any other means known to the writer. The vasodilatation acts to prevent or lessen the incidence of thrombosis and occlusion in vessels not already totally occluded, striking a well directed blow at the site of the disease. It forms the most efficient basis for the encouragement of collateral circulation.

Some claim that this effect is not permanent. Four years ago, however, the author first performed lumbar ganglionectomy for chronic occlusive arterial disease of the lower extremities with a large element of vasoconstriction in a patient age 47, with a pregangrenous toe.

The resultant vasodilatation has persisted at almost the normal level to the present time, and is attended with remarkably satisfactory results.

In the upper extremities the results are sometimes not quite so good as in the lower extremities, but the persistence of vasodilatation for an extended period is of great benefit and not obtainable otherwise. There are those who look with disfavor on ganglionectomy for these conditions, and it is true that the claudication is in many cases not thus relieved. However, those who have seen the disappointing results of other methods of treatment over a period of years, cannot deny that no procedure offers the degree of increased circulation obtainable by ganglionectomy in the properly selected case. No procedure offers greater insurance against the serious complications of progressive arterial disease. If ganglionectomy is to be done, it should be done early, because as the disease progresses the vasoconstrictor element gradually recedes. In thrombo-angiitis obliterans ganglionectomy should be promptly done on the less involved extremity as a prophylactic measure since the disease becomes bilateral in about 95 per cent of cases.

The operation of lumbar ganglionectomy as developed by the author[1] through a completely muscle-splitting extraperitoneal approach is easily and quickly performed by trained hands with very little danger to the patient. The period of hospitalization is shortened by this approach to five or six days. For the upper extremities the "preganglionic operations" are now in favor and the results are very promising.

SUMMARY

1. There are no effective well-recognized specific means of treatment of the various types of chronic occlusive arterial disease.

2. Rational treatment depends to a great extent on the results of a properly performed quantitative determination of the element of vasoconstriction in each extremity.

3. For patients with little or no vasoconstrictor element circulatory exercises and suction pressure therapy may be beneficial. Ligation of the main vein to the extremity has given worthwhile results in certain carefully selected cases.

4. For patients with a large or considerable element of vasoconstriction, conservative measures have been inadequate in the author's experience.

5. Lumbar ganglionectomy gives a greater, more continuous, and more persistent increase in circulation to the lower extremity with pronounced vasoconstriction element, than any other type of treatment. Preganglionic cervicothoracic sympathectomy gives comparable results in the upper extremity. The operations have a low mortality.

6. The vasodilatation following sympathectomy diminishes the likelihood of onset of thrombosis, and increases the collateral circulation, giving the greatest insurance against the serious complications of chronic occlusive arterial disease.

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PANCREATIC EXTRACT (ENZYME-FREE) IN THE TREATMENT OF DIABETIC AND ARTERIOSCLEROTIC GANGRENE*

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IN spite of skillful insulin administration, gangrene of diabetic origin is still very common. Survey of statistical data for the last decade[1,2,13,15,16,17,18,19,21,24] shows variations in the incidence of gangrene from 3.1 to 25 per cent with a mean average of 8.5 per cent. Comparative statistics compiled by Kramer[16] in 1932, showed an average of 6.28 per cent.

These figures, however, refer merely to the *incidence* of gangrene among the diabetics. As the cause of death, diabetic gangrene has advanced from a rather humble status to a very prominent position. Two or three decades ago it was near the bottom of the list as a cause of death among diabetics; within the last decade it has moved up considerably, and in some clinics is now third on the list. My survey of statistical data on gangrene as cause of death in diabetes yields a mean average of 24.6 per cent. This closely agrees with the 20 to 30 per cent range quoted by Edelen.[8] Thus, as a threat to life in diabetics, gangrene looms with increasing menace.

Several authors, while calling attention to this increase, attribute it to the lengthened life-span of the diabetic since the advent of insulin—a life-span which, presumably, may now include the "arteriosclerotic decades." It is difficult to decide at present whether this increased life-span actually benefits the higher age group, or whether the increase is merely due to greater survival in the lower age brackets. The question is still an open one.

It must also be borne in mind that atherosclerosis and diabetes are insepa-rable. This may be an important contributory factor in the occurrence of gangrene.

Insulin with all its subsequent improvements did not substantially influence the mortality nor the morbidity of gangrene. Joslin states that fewer and fewer diabetics now die of diabetes; he regards deaths due to coma as absolutely avoidable. Yet when gangrene develops, the outlook for the gangrenous extremity is still hopeless in the opinion of most authors. Many stress prophylaxis; this having failed, radical amputation is mandatory in all cases of moist gangrene. Somewhat greater latitude, however, is allowed for dry gangrene where more conservative treatment may be instituted. Some authors advise hot air, electric cradle and suction apparatus, as well as iodides, acetylcholine, etc. I shall deal later with some aspects of these conservative methods.

For a number of years we have obtained very favorable results by treating cases of diabetic and arteriosclerotic gangrene with various enzyme-free pancreatic extracts prepared and standardized according to our previous publications.[26,27,28,31] Some of our methods were reported before the International Physiological Congresses, in Rome in 1932,[31] and in Leningrad in 1935.[28]

The early rationale for using this substance was based mainly on the work of Frey and Kraut,[10] and of Vaquez and his co-workers,[25] who showed that the pancreas contains a vasodilator substance. My colleagues and I have since discovered and reported[26,27,28,31,32] that it possesses many other pharmacologic properties:

(A) We believe it to be a parasympathetic stimulant—perhaps a cholinergic hormone—for the following reasons:

1. It neutralizes the rise in blood pressure produced by epinephrine.
2. Topical application to the bullfrog eye constricts the pupil and neutralizes the dilator effect of epinephrine.
3. It increases peristalsis.

(B) This substance aids in fat metabolism, i.e., it lowers blood cholesterol and phospholipids after parenteral administration.

(C) In depancreatized dogs it prevents fatty degeneration of the liver and prolongs the life of the animal, as reported in Leningrad in 1935.[28]

(D) It causes appearance or increase in human urine of a substance related to choline, which is detected, like choline, by adding a solution of bismuth iodide in nitric acid to the urine.*

After injection of pancreatic extract, the quantity of brick red precipitate increases over a period of a few hours. In our experience there is a relationship between the quantitative appearance of this substance and actual clinical results.

(E) Our clinical impressions suggest that pancreatic extract prevents certain trophic changes.

We shall briefly summarize here a series of 100 cases treated with pancreatic extracts. This series comprises sixty cases of diabetic-atherosclerotic gangrene and forty cases of non-diabetic-atherosclerotic gangrene. The age range of the patients was from 44 to 78 years.

We divided all our diabetic cases treated with pancreatic extracts into two groups. The first consisted of those with beginning

dry gangrene, darkening of toes or fingers or both, and sloughs no larger than 1.5 cm. in diameter and approximately 0.25 cm. in depth if ulcerated. (Figs. 1 and 2A.) Moist spots were often present. This group comprised thirty-three cases. Of these, twenty-nine (88 per cent) were healed completely; two had amputations; other cases could not be followed up. This type of case responds best to pancreatic extract therapy.

The second group of diabetics comprised twenty-seven cases of more extensive gangrene. (Fig. 3A.) Here moisture was present in most cases. The results, while not so spectacular as in the first group, were, nevertheless, highly gratifying. Seventeen (63 per cent) were healed completely, with a maximum loss of one to three toes or loss of tissue to the extent of the necroses. Only seven came to amputation. It must be stated that of these seven, two coöperated poorly, while the other five were extremely toxic with the infection so far advanced that there could be no hope of recovery. In this latter group there were three deaths—one due to cerebral thrombosis and two due to pneumonia. Three cases could not be followed.

The only cases accepted for treatment with pancreatic extract were those not exceeding the degree of pathology shown in Figure 3A.

The group of forty non-diabetic-arteriosclerotic (Fig. 4), gangrene cases treated with pancreatic extract showed the following results: Complete recovery was obtained in twenty-seven (67.5 per cent), together with a markedly increased walking capacity. Four cases could not be followed. Amputation was necessary in nine, of whom five survived, two died of pneumonia, one of cerebral embolism, and one of progressive heart failure.

Some of the cases had been under observation for several years. Whenever the patients complained again of pains, leg cramps, and difficulty in walking, the treatment with pancreatic extract was repeated.

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* The test is as follows: Five drops of this reagent are added to 2 c.c. of urine in a small test tube. The tube is centrifuged for thirty seconds at a high speed or allowed to stand for six to twenty-four hours. The presence of a brick red precipitate adhering to the bottom of the tube indicates the presence of this substance in the urine. The quantity of brick-red precipitate gives an indication of the amount of this substance in the urine.

The following are a few illustrative cases:

CASE I. H. T., age 46 years, a white male clerk, complained of constant numbness and

On March 29, 1937, he returned following a slight injury to the middle toe of right foot, which he incurred while mowing the lawn. The toe became black and began to ooze profusely.

FIG. 1. Typical dry gangrene lesion.

tingling of his feet, marked limitation of effort, and intermittent claudication. He had been taking insulin since 1934. In the winter of 1935–36, he was treated for "soreness" of the middle toe of the right foot, which responded to rest in bed (seven months), diet, and higher insulin dosage. He first came to us in June 1936. He had been on a strict diet with 35 units of insulin daily.

Pulsations in both the dorsalis pedis and the posterior tibial arteries were absent. The middle toe of the right foot presented a purple red area and there was a serous ooze from a very small dorsal opening. Pachon oscillometric readings revealed zero oscillations below the left knee and less than one quarter below the right knee. The urine was negative for sugar. The blood sugar level was 96 mg. per 100 c.c.

The diabetes was obviously under control and no change in the patient's régime was made except for triweekly intramuscular injections of 2 c.c. of pancreatic hormone (Grant). His toe symptoms decreased considerably in severity; pancreatic hormone administration was consequently reduced to biweekly injections. Improvement continued, and soon he was no longer "foot conscious."

(Fig. 2A.) Examination elicited crepitation in the affected toe; osteomyelitis and fracture of the terminal phalanx were suspected and confirmed by x-ray. (Fig. 2B.) The patient was admitted to Temple University Hospital where Dr. Worth B. Forman performed a phalangectomy. Recovery was uneventful and the healing was complete. (Fig. 2C.) Insulin dosage was decreased. Walking capacity was greatly improved.

This case illustrates several interesting facts: (1) the importance of x-ray study in cases of diabetic gangrene for possible osteomyelitis; (2) an uneventful recovery following phalangectomy without further surgery; (3) the possibility of reducing the insulin dosage during the course of treatment with pancreatic extract.

CASE II. Mrs. K. C., 65 years old, was admitted to Bridgeton Hospital, on the Service of Dr. Leslie Myatt, in February 1937. There was advanced gangrene of the second and third toes on the left foot with discoloration and bleeding. Generalized arteriosclerosis was present. The patient was in pain and toxic, and her temperature was elevated. The left foot was bluish and discolored—a patchy type of discoloration with wet, moist, "smelly"

gangrene involving the second and third toes, with large patches, sloughing in character, on the dorsal as well as plantar surfaces of the

FIG. 2. Case I. A, gangrene of middle right toe. B, osteomyelitis and fracture of the terminal phalanx of the middle toe following injury.

FIG. 2C. Case I, six weeks after phalangectomy.

foot. The skin of the large toe was markedly discolored and blistered. (Fig. 3A.) Her diabetes was under control.

Pancreatic hormone (Grant) was administered in doses of 2 c.c. twice daily for three weeks, and then every other day. The response was beyond expectations. A photograph of the same case three months later (6/10/37) is shown in Figure 3B. The patient does all her housework, can walk one-half mile daily without difficulty, and her insulin dosage has been reduced from 30 units daily upon admission, to 10 units daily.

This is a borderline case, in which the prognosis must be guarded. Though our greatest number of failures has been among this type of case, a result such as this is very encouraging.

CASE III. Mrs. L. P., 74 years old, was seen in consultation with Dr. George A. McGinnis of Norristown, Pa. on September 13, 1936. The following is an abstract of the case by Dr. McGinnis:

"Patient suffered from arteriosclerotic senile, non-diabetic gangrene. She had severe pain in her left foot and right hand; the left great toe and the right thumb were black to the first joint. There was no radial pulse, and the posterior and anterior tibial pulses were also absent. Pancreatic extract (Wolffe), 2 c.c., was given intramuscularly daily for twelve days, then every other day. The pain in the foot and hand subsided after the first twelve days and their appearance became more normal; there

A   B

Fig. 3. Case II. A, advanced gangrene of second and third toes of the left foot. B, three months later. Notice reappearance of the matrix.

A   B
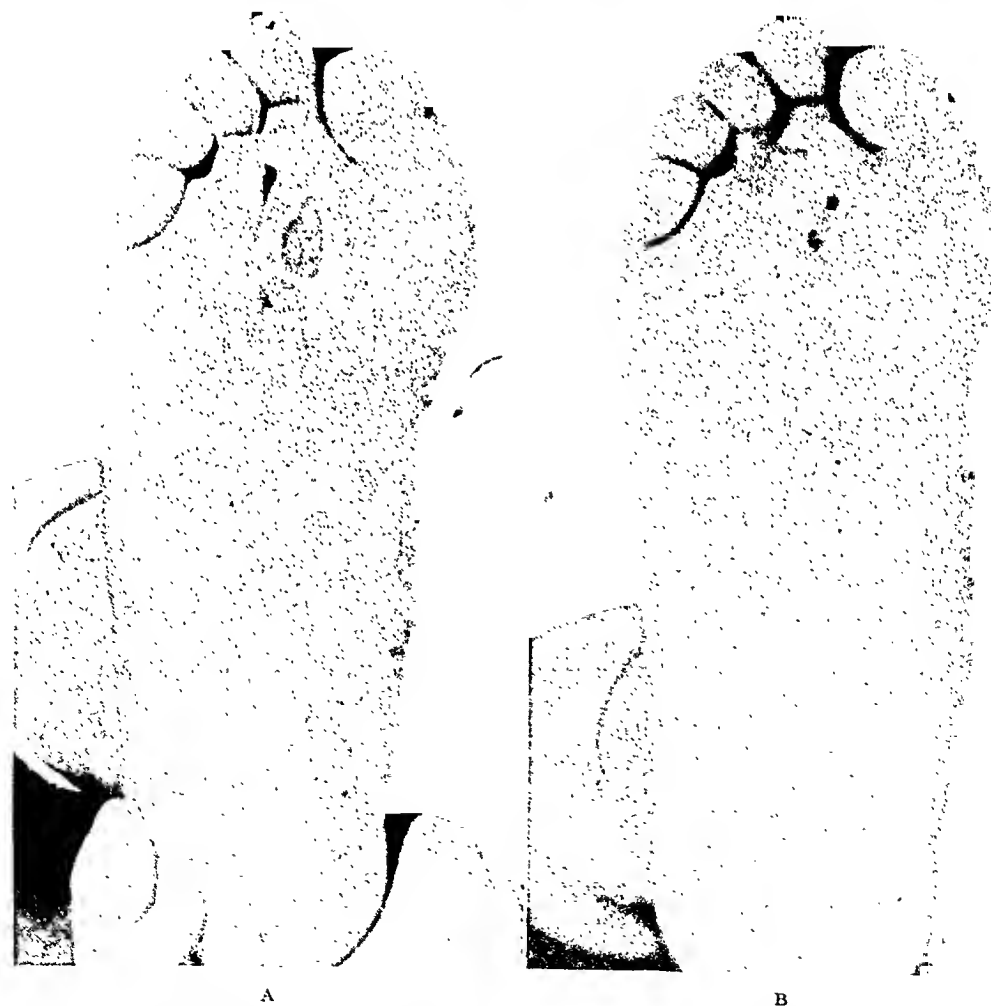
Fig. 4. A, non-diabetic arteriosclerotic gangrene. B, after treatment with pancreatic extract.

seemed to be a gradual return of circulation. Injections were continued (2 c.c. twice weekly) for twelve more weeks. No other medication

N. J. In 1934 he very gradually developed the usual symptoms of obliterative arteritis. He had cyanosis and coldness of both feet and

FIG. 5. Case VII. A, before treatment. Anterior half of foot red, swollen and very painful. Small gangrenous area at edge of nail of first toe. Blood pressure 212/110. B, after ten days' treatment. No pain during week. Necrotic area healing. Less edema. Blood pressure 160/95.
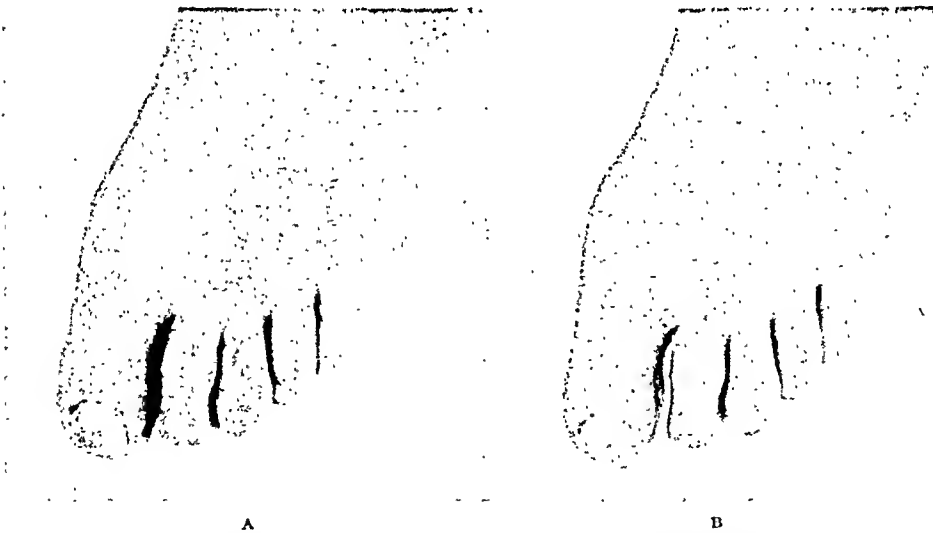
FIG. 6. Case VII. A, after three weeks' treatment. Necrotic area completely healed. Much less edema and redness. No pain or discomfort. Blood pressure 150/92. B, after one month of treatment. There is still some redness of toes when foot is dependent, but edema is much less marked. Blood pressure 144/92.

except sedatives and laxatives was given. She made a perfect recovery. Color was restored to both hand and foot; the right hand was somewhat claw-like in appearance due to arthritic changes in the joints; this remained unaffected. The result following the use of pancreatic extract in this case was spectacular."

CASE IV. J. H., a white male of 57 years, was treated by Dr. C. P. Lummis, of Salem,

ankles, most marked in the left foot. He also had slight pain and moderate claudication. Following a severe illness (rupture of gastric ulcer and operation) in March 1935, his arteritis became much worse. Rather severe pains developed, requiring drugs for relief; there was an absence of the posterior tibial and dorsalis pedis pulses in both feet and marked rubor (grade 3) was noted.

He was started on pancreatic tissue extract (Sharp & Dohme) in April 1935 with a dose gradually increased to 3 c.c. every three days.

Pancreatic extract has been continued in 3 c.c. doses every three or four days and he is greatly improved. The ulcer on his toe is completely
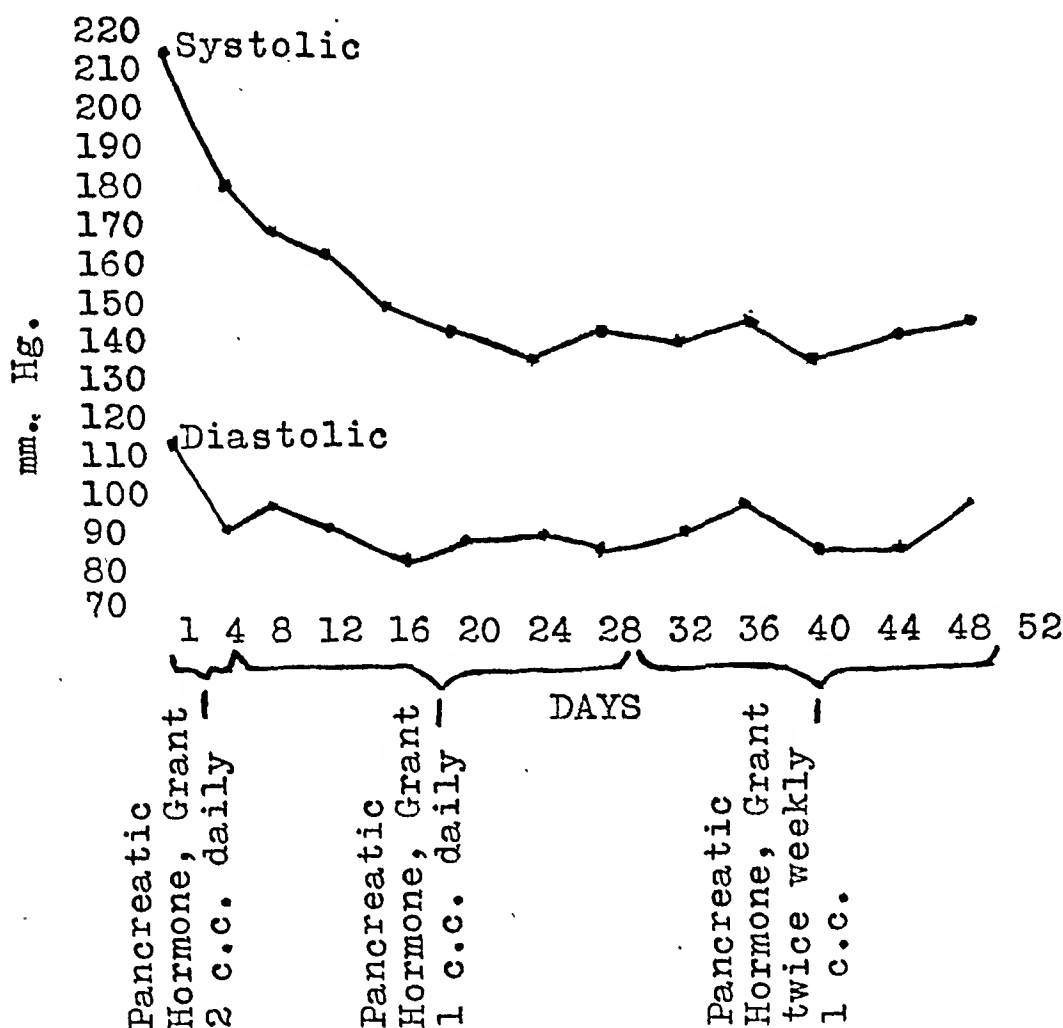
FIG. 7. Case VII. Blood pressure chart.

In about one month, marked improvement took place and he was able partly to resume work. All the symptoms gradually improved. Rubor of grade 1 was still present; but there was no pain. Claudication was present, but was much improved, he can walk about 4 blocks without pain. He continued with pancreatic tissue extract until August 1935, when he discontinued treatment against advice. In November 1935 he developed severe pain, rubor grade 3, and very dark blue, almost black, discoloration of the second and third toes of his right foot. An ulcerated area developed at the distal extremity of the second toe and it was thought amputation might be necessary.

Pancreatic extract administration was again started and the dose rapidly increased until 3 c.c. was given every third day. In about four weeks, marked improvement was noted, and in December 1935, he resumed part-time work.

healed; the pain has entirely gone; rubor grade 1 is present and he can now walk about four blocks without claudication. No other medical treatment was given; but he has used Buerger's exercises and contrast baths.

CASE V. Mrs. J. Y., white, 62 years old, was admitted to the Wilmington General Hospital, service of Dr. J. M. Barsky. She had had diabetes for four years. Two days before admission, she noticed soreness in the feet, a tired feeling, weakness, headache, and feeling of complete exhaustion, even though she did only the usual amount of housework. The patient was discharged with diabetes controlled, but returned six months later, with typical dark red blisters on the toes of the left foot. The blisters ruptured, leaving small gangrenous areas. Two weeks of bed rest and control of the diabetes failed to improve the appearance of the feet. Pancreatic hormone was then administered, and resulted in com-

plete healing. There was a recurrence about nine months later. Pancreatic hormone was again administered, followed again by complete healing.

CASE VI. G. K. R., male, white, aged 76, was admitted to the service of Dr. Barsky, in the Wilmington General Hospital, Wilmington, Delaware. The patient had diabetes of five years' standing, and took 30 units of insulin at the time of admission. He complained of pain and ulceration in the left foot and a purulent discharging sinus at the base of the left big toe. There was intermittent claudication of the left leg. On dependent position, the left leg became red and purple in color. X-ray showed a destructive bone process particularly marked in the distal half of the first metatarsal and the end of the first phalanx of the great toe. Treatment consisted of stabilization of the diabetes; and the administration of pancreatic extract. The patient was discharged completely healed.

CASE VII. C. B., white male, 74 years of age, was treated by Dr. Clifford C. Baker of Vineland, New Jersey. His past medical history was essentially negative. Mild symptoms of hypertension had been present during the past two years, but otherwise his recent health had been good. For several weeks the patient had noticed some edema of the left foot and complained of a feeling of coldness and occasional numbness of the toes of the left foot. Several days before he began to have burning pain in the toes and the anterior half of the affected foot and noticed that in this region there was a marked redness which would disappear when the foot and leg were elevated. At the medial border of the nail of the first toe there appeared a small area of discoloration of the soft tissues and this gradually increased in size over the course of several days.

The patient was normally developed but slightly undernourished, although he appeared to be in good general health. The heart was slightly enlarged, with sounds of fair quality and regular rhythm. The pulse rate was 84 and the blood pressure 212/110. The peripheral vessels were somewhat sclerotic and beaded.

Several small varicosities were present on the left leg, the toes and the anterior half of the foot were markedly swollen and red, with the red portion becoming blanched when the leg was elevated. The dorsalis pedis and the posterior tibial pulsations could not be felt. At the medial edge of the nail of the first toe there was a small area of discoloration.

The urine was negative for sugar but showed a very faint trace of albumin.

A diagnosis of early arteriosclerotic gangrene was made.

A sterile dressing was applied to the necrotic area and the patient advised to continue with a moderate amount of walking. A diet of 1,100 calories containing carbohydrate 100 gm., protein 60 gm., and fat 50 gm., was ordered and the patient was asked to take ½ ounce spiritus frumenti b.i.d. The patient was given intramuscular injections of 2 c.c. of pancreatic hormone daily for the first four days and thereafter 1 c.c. daily.

By the fourth day of treatment the patient experienced marked relief of pain and the local necrosis on the first toe showed no signs of further increase in size. There was gradual improvement in the general appearance of the foot and in less than three weeks the necrotic area had completely healed. Blood pressure (systolic and diastolic) showed a gradual decrease as shown by the accompanying graph. After the first month the injections of pancreatic hormone were given twice weekly in 1 c.c. doses, rather than daily. Diet and other treatment was not changed. The patient continued to improve and his blood pressure averaged 145/95. Subjectively he felt in better health than he had for several months previous to his illness.

SUMMARY

Patients in my series of 100 cases summarized earlier in the article, seemed to do very well, presenting about 75 per cent of complete healing. Most of them were treated conservatively. It must be stressed that injections of pancreatic extract did not constitute the sole treatment in all the cases. The extract was administered in doses of from 1 to 3 c.c., either daily or on alternate days, depending on indications, *in addition* to an adequate diabetic regimen. Nor were other measures neglected, such as proper hygiene, asepsis, short wave diathermy, low fat diet, etc. Typical management of a case included:

1. Papaverine hydrochloride gr. ¼ Acetylsalicylic acid, gr. 5
   Every three hours for pain.
2. Keeping the extremity warm. Appropriate non-irritating dry dressings.

3. Low cholesterol diet and indicated amounts of carbohydrates. Insulin when indicated.

4. Spirit. frumenti ℥ ss, b.i.d.

The patients were encouraged to be up and about as soon as possible, in order to aid the utilization of carbohydrates and fats by increasing energy requirement.

Since there is an optimal temperature which is most favorable for healing, we felt that the electric cradle might prove injurious in many cases and we therefore did not encourage its use. Similar objections based on the degree of stimulation may be raised against the various types of positive and negative pressure apparatus and for this reason these were not used in our cases.

The usual diabetic management fails in many cases of gangrene, necessitating radical surgery. I attribute this to the lack in insulin of some substance present in the pancreatic extract (desympatone). In some cases insulin alone seems to disturb muscle physiology. This can be judged from the fact that many diabetics with angina pectoris have refused to take insulin or learned to be cautious about it, because anginal seizures were often precipitated following the administration of even small amounts.[34] On the other hand, when these patients are given insulin with pancreatic extract, their tolerance is restored.

This may be due to the fact that in many diabetics there is a disturbance both in the lipoid and carbohydrate metabolism, and the effect of insulin, which is directed against the carbohydrate disorder alone, tends to produce a metabolic disequilibrium between the lipoid-carbohydrate relationship. Further studies along these lines are being conducted by my associate, Dr. Digilio, and other members of our group.

The active substance present in the enzyme-free pancreatic extract, which is neither histamine nor choline, exerts a beneficial influence upon lipoid metabolism, as well as upon muscle metabolism in general. As a corollary to this, it may be that the combination of insulin, pancreatic

extract and a diet low in fats, will prevent the early appearance of atherosclerosis in diabetes. In the event of the latter, it is possible to expect a decreased incidence of diabetic gangrene.

CONCLUSION

Pancreatic extract (enzyme-free) proved of great value as an additional therapeutic agent in the management of diabetic and arteriosclerotic gangrene. It not only produces an early arrest of pathologic processes, but seems to stimulate repair more rapidly and more completely than any other conservative method in my experience.

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AN IMPROVED CESAREAN SECTION TECHNIQUE

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MUCH has been written recently on the increasing incidence of cesarean section with its accompanying high mortality due to hemorrhage and infection. The abnormal death rate, well over 60 per cent in 1876, induced Porro of Pavia to attempt to overcome the dangers by doing a supravaginal amputation of the uterus after the delivery of the child. However, the Porro operation did not lessen the maternal mortality.

The greatest dangers and complications of cesarean section had come from the uterine incision, which tended to produce hemorrhage and peritonitis, the latter from the seepage of lochia into the abdominal cavity. In 1882 Max Sanger successfully sutured the uterine wound with silver wire and silk. This improved the operation of cesarean section and lowered the death rate by some 20 per cent. Notwithstanding the improved aseptic technique, such complications as hemorrhage, infection, peritonitis, peritoneal adhesions and rupture of the uterus during subsequent labor, occured all too frequently. To overcome these complications low cervical section was revived and practiced in 1906 by Frank of Cologne, Germany, although when it had been performed a century before by Osiander and Joerg, it had met with little success.

The excellent work of Sellheim, Döderlein, and Latzko helped to bring the low cervical operation back into vogue, and by the writings of Beck, De Lee and, more recently, Phaneuf, this method was introduced on this continent.

Gottschalk of Berlin, in 1911, and Portes of Paris, in 1924, added a further point when they brought the uterus out of the abdomen (temporary exteriorization) in infected cases and kept it out until the infection was controlled. Then the uterus, which had partially or completely involuted, was returned to the abdomen or, if still infected, was removed.

Extreme conservatism is now advocated in the employment of cesarean section; it should be resorted to only in the unquestioned indications, such as contracted pelvis, cephalopelvic disproportions, tumors obstructing the pelvic outlet, stenosis of cervix, advanced heart disease or tuberculosis, in some cases placenta previa, etc., according to recent reports, most of which recommended a trial of labor up to two hours after the complete dilatation of the cervix. It is stated that many parturient women would deliver if left alone and given a trial of labor. But it is often this trial of labor that exhausts these women and has proved the turning point against them, thereby increasing the maternal mortality.

The trying ordeal which a difficult labor inflicts on women is not, I think, sufficiently appreciated. Excessive loss of blood, lacerated cervix, injuries to the bladder, bowel, vagina and perineum, retained parts of placenta and membranes, subsequent infection, septicemia, phlebitis, endometritis and endocervicitis are frequent causes of morbidity in women. These factors, in addition to the mental and physical pain of difficult labor make it worthwhile to attempt alleviation if this should be possible.

Few women are the same mentally or physically after a difficult confinement. The vaginal canal is often so torn, stretched and injured that proper marital relations have not only become less agreeable, but in many instances painful or even unbearable. Many marriages are harmed on this score alone. The large number of suspensions, plastic operations for prolapsus uteri,

repair of cervix or vagina, cystocele, rectocele, eoaptation of widely separated recti, the increasing need for the application of radium to the cervix are testimony to the extent of obstetrical trauma. Pelvic adhesions caused by puerperal infections often necessitate later operation. Six hundred operations of this type were done at the Vancouver General Hospital in 1936. Carcinoma rarely occurs in a cervix that has never been dilated or torn by childbirth.

It is also true that few babies come unhurt through the birth canal during a difficult labor, especially if it is the first. The squeezing and compression even in normal cases, to say nothing of the abnormal ones, cannot but be undesirable. The old teaching that this process accumulates carbon dioxide in the blood stream to stimulate the respiratory center has now been exploded. Last year at the Vancouver General Hospital the fifty-seven stillbirths and thirty premature deaths were nearly all due to difficult labor. This mortality could be greatly reduced if not entirely eliminated by timely cesarean section.

Cesarean section is done because the abdominal delivery offers the best chances for mother and child and avoids a vaginal delivery which would be multilating to the mother and possibly fatal to the baby. Experience has taught me that cesarean section, especially the low operation, done before labor sets in, leaves little to be desired. I am not unmindful of the high mortality and morbidity of section in country-wide statistics. However, I think that both would have been negligible had section been done on properly indicated cases before labor had set in. With a technique which permits very little loss of blood and no amniotic spill, few complications appear. Infections and pulmonary embolism seldom arise under aseptic technique if operation is done early and active movements are begun soon after. The repeated examinations, the versions, use of forceps, and the exertion of a trial labor, however short, lower the patient's

resistance, paving the way for infection and other complications.

Cesarean section has not reduced maternal mortality, because of delay in operating and the type of operation done. Severe labor and numerous unnecessary vaginal examinations are a bad prelude. Unjustifiable operations are done on eclamptic, nephritic and septic patients. In addition, one must emphasize that only qualified surgeons should undertake such procedures.

However, there is no doubt that cesarean section performed by the technique now in vogue entails a great loss of blood with an amniotic spill which all too frequently enters the abdominal cavity. Even in the hands of competent surgeons the hemorrhage is often considerable, while in the hands of the less experienced it is often so great that postoperative shock and complications produce a high mortality.

The technique reported here should assist not only the surgeon, but also the occasional operator. It prevents amniotic spill and blood loss from the uterine wall incision. Too often tremendous hemorrhage is caused by cutting across the larger vessels in opening the uterus, since these vessels are difficult to see in the gush of amniotic fluid.

TECHNIQUE

Make an incision through the skin, subcutaneous connective tissues and anterior sheath of the rectus muscle near its medial border from the umbilicus to the pubes. Free the rectus muscle from the mesial border of its sheath and retract it outward. Open the abdomen by making an incision through the transversalis fascia and peritoneum, being careful to avoid the urinary bladder (which was previously emptied with a catheter).

The anterior surface of the uterus is now exposed the full length of the incision. Laparotomy pads should be arranged around the abdominal opening. If the low cervical cesarean section is preferred to the classical, make a transverse incision across the uterine peritoneum about an

inch above the bladder reflection. Dissect the lower flap of the peritoneum with the bladder from the anterior surface of the uterus and cervix. Also dissect the upper transverse flap of the peritoneum from the anterior surface of the uterus for such a distance as the longitudinal incision requires. Place two Allis tacks on the uterine wall at the top of the intended incision and make a small quarter inch opening between them. Insert a suction tube through this opening into the uterine cavity and syphon off all the amniotic fluid into a large receptacle.

Remove the suction tube and insert through the aperture in the uterine wall two curved (DeMuth) cesarean forceps (Fig. 1) which have been specially designed for this purpose. Clamp the uterine wall gently but firmly and make a 7 inch incision between the clamps. Note that very little bleeding has occurred and that no amniotic fluid is present in the uterine cavity. Turn the cesarean forceps on their side; this converts the uterine opening into an oval through which the fetus, placenta and membranes can be easily removed. Lift the baby out carefully. Sever the umbilical cord between two clamps, and pass the baby over to an assistant. Inject 1 c.c. of pituitrin into the uterine wall. Wait a few minutes and then remove the placenta and membranes. If at this stage of the operation the removal of placenta and membranes is not hurried there will be much less bleeding from the placental site.

Next see to it that the cervix is open. If not, dilate it with two fingers. Remove the cesarean clamps. The opening in the uterine wall will contract to nearly half its original size as the remainder of the uterus has already contracted. Close the uterine wall opening with three layers of continuous suture of No. 2 chromic catgut. Reperitonealize the uterine suture line.

Remove all abdominal wall pads. Close the abdomen in three layers in the usual manner without drainage, making sure to coapt the widely separated recti muscles. Apply a postoperative abdominal elastic

wound support. Upon the patient's return to her room, give 1,000 c.c. of 5 per cent glucose-saline solution every six hours for the first two days.
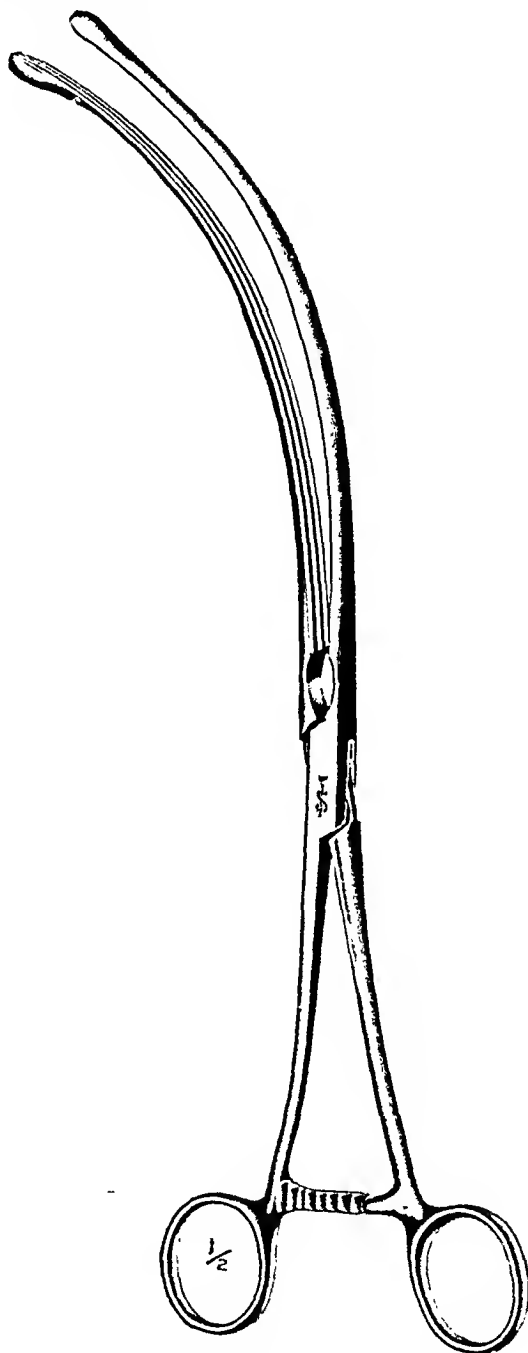
Fig. 1. DeMuth cesarean clamp.[1]

The amniotic spill, although it is physiologic to the amniotic cavity, is not so to the peritoneum. Most of the adhesions which occur following section are due to the exudative peritonitis caused by the spill of amniotic fluid or seepage of lochia through the uterine incision. Drawing off this fluid through a trocar causes the uterus to con-

[1] Made by Kny-Scheerer Corporation.

tract; with the removal of the child it contracts further. This permits one to lift up the contracting uterus in the abdomen so that an assistant can hold and gently compress it. It also enables the assistant to aid the contracting uterus by lateral pressure, and to compress the uterine vessels in each broad ligament if the need arises, while the surgeon sutures the wound in the uterus. Several pads are placed on the abdomen under a postoperative elastic support. This stimulates and maintains the uterus in contraction. It also restores the abdominal pressure so suddenly relieved.

I have had the good fortune not to have had a single maternal or fetal death from cesarean section in seventy-three cases operated upon over a period of seventeen years. No serious postoperative disturbances have been encountered beyond the usual effects incident to any major abdominal operation.

Of course, cesarean section is not to be done on every borderline patient by any physician who thinks himself capable. But there are few major abdominal operations the technique of which could be mastered more easily. With better suturing of the uterine wall, more timely operations, a technique which permits little loss of blood and amniotic fluid, and little or no infection, there is only a slight possibility of a weak uterine scar. There is, therefore, little risk of a rupture of the uterus in a subsequent pregnancy.

SUMMARY

1. Cesarean operation, when indicated, should be done before labor sets in.

2. Excessive vaginal examination prior to cesarean section is to be avoided.

3. A new technique is described with
   (a) Puncture of the uterus.
   (b) Syphoning off the amniotic fluid.
   (c) Insertion of specially designed cesarean clamps to prevent bleeding from the uterine wall.
   (d) Application of postoperative elastic wound support to maintain uterine contraction and restoration of the abdominal pressure, which the emptying of the uterus has relieved.

A MODIFIED CIRCUMCISION SUTURE TECHNIQUE

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THE classical method of suture in the operation of circumcision is to approximate the cut skin edge to the

FIG. 1. Diagram demonstrating the subcuticular mattress suture going from without inward through the trimmed edge of the mucous membrane and taking a transverse subcuticular bite on the inside of the everted skin margin, finally being brought from within outward through the mucous membrane. The arrows show the direction of the suture at the frenum.

trimmed mucous membrane by interrupted sutures penetrating these layers. Occasionally, there results a "sawtooth" skin margin, the result of one or several sutures cutting through the skin. Such a necrosis is more apt to occur when too large a bite is included in the ligature.

A perfect union of skin and mucous membrane may be obtained by using interrupted subcuticular mattress sutures, inserted first through the mucous membrane from without inward, then taking a sub-

cuticular bite in the everted skin, the suture being passed transversely on the inside of the everted skin edge and back

FIG. 2. Placement of the subcuticular mattress sutures at the midline dorsally, at the frenum and at equally spaced points on the lateral aspect.
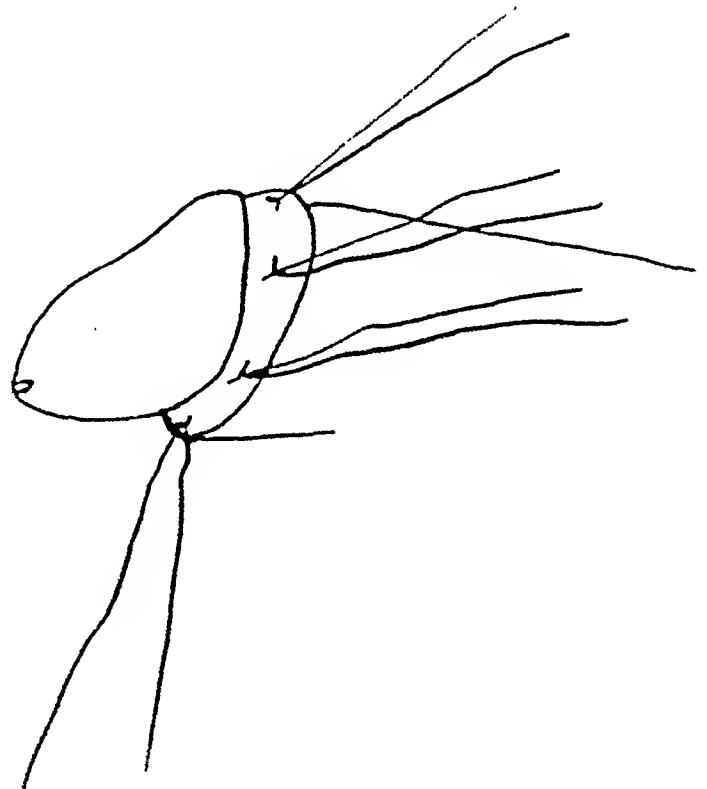
FIG. 3. Sutures tied and the ends left long to be tied over a piece of vaseline gauze.

again through the mucous membrane from within outward. The sutures are

placed at the frenum and dorsal aspects, then used as tractors until two such sutures are evenly placed on each side of the midline. The ends are tied and left long, to be tied again over a strip of vaseline gauze, which, when separating in a week or ten days, leaves an intact skin margin united to the mucous membrane.

By placing the sutures on the inside of the cut skin margin and not bringing the loop through the entire thickness of skin, one secures a fine cosmetic appearance, which requires a minimum of postoperative attention.

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TOTAL THYROIDECTOMY IN THE TREATMENT OF ANGINA PECTORIS

LATE RESULTS IN FOURTEEN CASES

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A GREAT number of total thyroidectomies have been done for patients suffering from angina pectoris or congestive heart failure since the introduction of this plan by Blumgart, Levine and Berlin. Sufficient time has now elapsed for the immediate results to be recorded. The primary problem is really a medical one, for only by careful study and selection of cases can the best ultimate results be obtained. We wish to add to the literature a report of our experiences with fourteen total thyroidectomies which were done for angina pectoris.

Each patient in the series had been given every advantage of medical management and had reached the state of invalidism. Each patient was carefully watched and studied so that not only the physical condition but also the cardiac and renal status was known. All had renal functions within normal limits. There was evidence of coronary sclerosis in all the cases and in one there was evidence of two small healed infarcts. The presence of a healed infarct has not been considered a contraindication to surgery.

The basal metabolic reading is very important, since it is not advisable to recommend total ablation if the rate is below minus fifteen. In this series the metabolic readings were all within normal limits. The anginal syndrome may be improved by elevating the metabolism in some of the cases with a low basal rate and a low blood pressure. The mechanism is an improvement in the coronary circulation.

We believe that the lessening of adrenal effect is responsible for the dramatic relief of pain in the angina pectoris cases, and a separate explanation of the results obtained in decompensated hearts must rest in the lowered metabolic demand, a limit which the damaged heart can supply. The lowering of the basal metabolic level is not an immediate phenomenon, but occurs about four to six weeks after the total ablation has been done.

The patients have been prepared by being placed in the hospital for two or three days previous to operation in order that they may become adapted to the surroundings. A sedative is given the night before and the morning of the operation. The surgery has been done by one of us (J. R. P.). The operations have been performed under local anesthetic supplemented by a little ethylene gas; in two cases the operation was done entirely under local anesthesia. The operation is not difficult and can be done in forty-five minutes to one hour. Every particle of the gland must be removed; otherwise there will be a regeneration of the remaining part and the temporary benefit will be lost. In addition, the recurrent laryngeal nerves must not be injured. However, the anatomic relation of these nerves has been so well worked out that this danger is minimal. There has been no cord paralysis in this series. The parathyroids, as a usual thing, are not greatly endangered; at least one has been demonstrated in every case. There was a transient parathyroid tetany in one case, which was easily controlled by calcium, cod liver oil and parathormone.

All the patients were operated on more than eighteen months ago, the first one

on April 12, 1934. There were nine men and five women in the series, their ages varying between 40 and 70 years.

These patients stand total removal very well, the general operative risk being between 5 and 10 per cent. There were two operative deaths in the series. The first occurred in a man, aged 70, who had a marked coronary sclerosis and had had two previous attacks of occlusion. His death was due to an acute occlusion, as shown at post-mortem examination. The second was in a man, aged 56, whose death was the result of a cerebral embolus from aortic arteriosclerotic ulcerations.

There have been seven excellent results and two cases with good results. Five patients are living over two years after operation. One individual had excellent results for one year, but has had two attacks of coronary occlusion since that time. Another died six weeks after operation of coronary occlusion. Still another died seventeen months after operation of coronary occlusion, though he had had fair results before his death.

Since surgical myxedema does not begin to manifest itself until four to six weeks after the whole thyroid is removed, there is no need for thyroid extract until that time. These patients take one tenth grain of active thyroid substance two or three times each day, which overcomes the greater portion, but not all the myxedema. One patient, although with a well marked myxedema, has had no distressing symptoms and consequently takes no thyroid extract.

Two patients have had very interesting experiences following total thyroidectomy. The first, a man who two years ago had a total removal for severe angina, about six weeks ago presented himself with a ruptured gangrenous appendix. He was operated on for this and had a very easy postoperative convalescence. The second, a woman who twenty-one months ago had a total removal for congestive failure with angina, has since conceived and carried the pregnancy to term without decompensation or pain. Her baby is now five months old and is perfectly normal.

Name	Age	Occupation	Date of Operation	Result
M. L. R.....	44	Clothier	4-12-34	Excellent.
H. C. H.....	46	Merchant	5-26-34	Good.
L. T. P......	49	Contractor	5-28-34	Good—died 12-10-35, coronary occlusion, 17 months after operation.
A. M........	51	Merchant	6-2-34	Excellent.
J. K........	70	Ranchman	6-25-34	Died immediately after operation, coronary occlusion.
W. H........	50	Theater	8-17-34	Excellent.
Mrs. C. A. P.	40	Housewife	10-9-34	Fair—excellent for one year, two attacks since.
N. T........	50	Farmer	1-21-35	Relief for six weeks, death due to coronary occlusion.
Mrs. L. H....	48	Housewife	8-19-35	Good.
Mrs. M. B...	35	Housewife	9-30-35	Excellent.
Mrs. B. E. G.	25	Housewife	9-30-35	Excellent.
Mrs. E. F....	59	Housewife	10-15-35	Excellent.
J. C. N......	45	Plumber	10-23-35	Excellent.
E. K. N.....	56	Ranchman	2-5-36	Died, cerebral embolus.

Not one in our series feels that he or she is cured. All of them live well within their pain range, yet each one is better and would gladly repeat the measure if necessary. They are all rehabilitated cardiac invalids. The present level of improved status fully justifies the use of total ablation of the thyroid gland in properly selected cases of angina pectoris.

SUMMARY

A series of fourteen patients, who had had total thyroidectomies at least two years previously, is reported. All of these patients were suffering from angina pectoris of the most severe form. All showed some degree of coronary sclerosis and several presented definite evidence of cardiac infarction.

We feel, from the evidence presented, that while none of these patients may be considered cured, the present level of improved status fully justifies the use of total ablation of the thyroid gland in properly selected cases of angina pectoris.

MORPHINE AS A FACTOR IN POSTOPERATIVE VOMITING

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AUTHORITIES generally agree that in some people morphine may cause nausea and vomiting, but the frequency of these symptoms is not so generally appreciated. Postoperative vomiting is commonly ascribed to the anesthetic, although, aside from the anesthetic, a preoperative hypodermic containing morphine is given and a surgical operation is performed. The ensuing vomiting may be due to any one or more of these procedures. Ordinarily it is not definitely determined which of them is the important factor.

In order to test out the morphine factor, this drug was given the night before operation to 200 consecutive surgical patients at the Immanuel Hospital. In this way the effects of the drug were determined and the factors of anesthetic and operation were eliminated. In a few of the cases the morphine was given hypodermically. However, as a matter of convenience, in most of the cases it was given orally (gr. ¼) with sodium bicarbonate in a capsule. Sollman has stated: "Morphine tends to produce nausea and vomiting and thus to disturb digestion. The effect is independent of the mode of administration, the action being central."

If the patient slept well and had no untoward symptoms, we felt that no unusual susceptibility to the opiate existed. However, if the patient developed nausea, vomiting, headache, or marked restlessness during the night, idiosyncrasy was considered to be present and some other opiate was substituted in the preoperative hypodermic. This series naturally did not include emergency cases where time did not permit the above procedure to be followed.

In cases of morphine idiosyncrasy codeine was usually used as a substitute, as this narcotic was usually better tolerated. The only objection to the routine use of codeine as a pre- and postoperative narcotic was that larger and more frequent doses were required to give the same analgesic narcotic action. The dose of codeine usually used in the preoperative hypodermic was 1 gr.

The following table illustrates the results obtained:

	Number	Percentage
Cases studied.................	200	
Morphine idiosyncrasies........	25	12.5
Postoperative vomiting in non-sensitive patients...........	...	36.5
Anesthesia used		
Avertin-ether..............	...	74.5
Nitrous oxide-ether.........	...	11.0
Spinal....................	...	10.5
Miscellaneous..............	...	4.0

Morphine idiosyncrasy thus existed in 12.5 per cent of 200 consecutive surgical cases.

When morphine idiosyncrasy is not previously tested, it is a common practice to give morphine to patients who are quite uncomfortable with vomiting. In these cases a vicious circle is produced and vomiting continues. This unfortunate mistake may be prevented by the method described above.

CONCLUSIONS

Morphine is a much more frequent cause of postoperative vomiting than is generally thought.

It is suggested that, if morphine is to be used, a preliminary dose be given the evening before operation to test the patient for idiosyncrasy.

In case of idiosyncrasy to this drug it is advisable to substitute some other sedative before and after operation.

A CASE OF PERIOSTEAL SARCOMA OF THE HUMERUS TREATED BY RESECTING, BOILING AND REPLANTING THE BONE*

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IN a paper published in 1936,[1] I described very briefly a case of osteogenic sarcoma of the humerus treated by resecting, boiling and replanting the bone. The bone was boiled in order to kill the tumor tissue, and replanted so that its calcium framework would support the soft tissues until new bone had developed. As the old bone had the most suitable shape and structure, it was preferable to use it for support instead of, for example, prepared bone such as os purum. The healing was primary. After the operation, there was no local recurrence, but roentgenograms two and one-half months later showed pulmonary metastasis which caused the death of the patient about fifteen and one-half months after the operation.

CASE REPORT

J. E. K., male, 16 years of age, was admitted July 30, 1935. The past history was negative except for measles during childhood. About Christmas time of 1934 the patient fell on the ice and hit his left shoulder. Although the immediate swelling was not great, at about the following Easter, April 1935, the left upper arm began to swell. The patient experienced no pain or tenderness, however, and no redness was observed. He noticed no weakness in his arm and had no difficulty in moving the shoulder joint. There was no loss of weight, no fatigue and no cough.

A series of Roentgen treatments had been given before admission for six days begin-ning May 31, and a second similar series beginning July 22.

At admission on July 30, 1935 the physical examination was entirely negative except that in the upper half of the left upper arm a spindle-shaped swelling was found. The skin was brownish-red in color. No distended veins were seen. Some increase of heat could be felt. On palpation the upper half of the arm was found to be firm and somewhat thickened, while on the anterior surface a somewhat more distinctly raised ridge was palpable. There was no crepitation or tenderness. The patient had good mobility in the shoulder joint, but could not abduct his arm completely upwards, lacking about fifteen degrees. The mobility of the arm was otherwise normal. There was some atrophy in the musculature of the upper arm, but the strength of the forearm and hand was fairly good. No enlarged lymph nodes were palpable in the axilla, nor in the supraclavicular or infraclavicular regions.

Examination of the blood showed the following: R.B.C. 4,400,000; W.B.C. 7,200; differential count: 77 per cent neutrophils, 5 per cent large lymphocytes, 15 per cent small lymphocytes, 1 per cent basophiles, 2 per cent monocytes.

X-ray examination disclosed an osteogenic sarcoma of the upper half of the left humerus. (Fig. 1A.) The chest plate showed no metastases.

On August 8, 1935, surgical resection, boiling and replantation of humerus together with implantation of os purum were performed. Under ether anesthesia an incision was made in the sulcus bicipitalis lateralis. The soft tissues were divided down to the periosteum and the latter was freed up over a wide area.

* Translated from the Swedish by Clifford C. Franseen, M.D., Boston, Mass.

The lower part of the shaft of the humerus was covered with layers of periosteal new bone, but no tumor masses were visible. An osteotomy

about the thorax, upper arm, forearm, and hand. The wound healed by first intention.

The pathologic diagnosis of telangiectatic
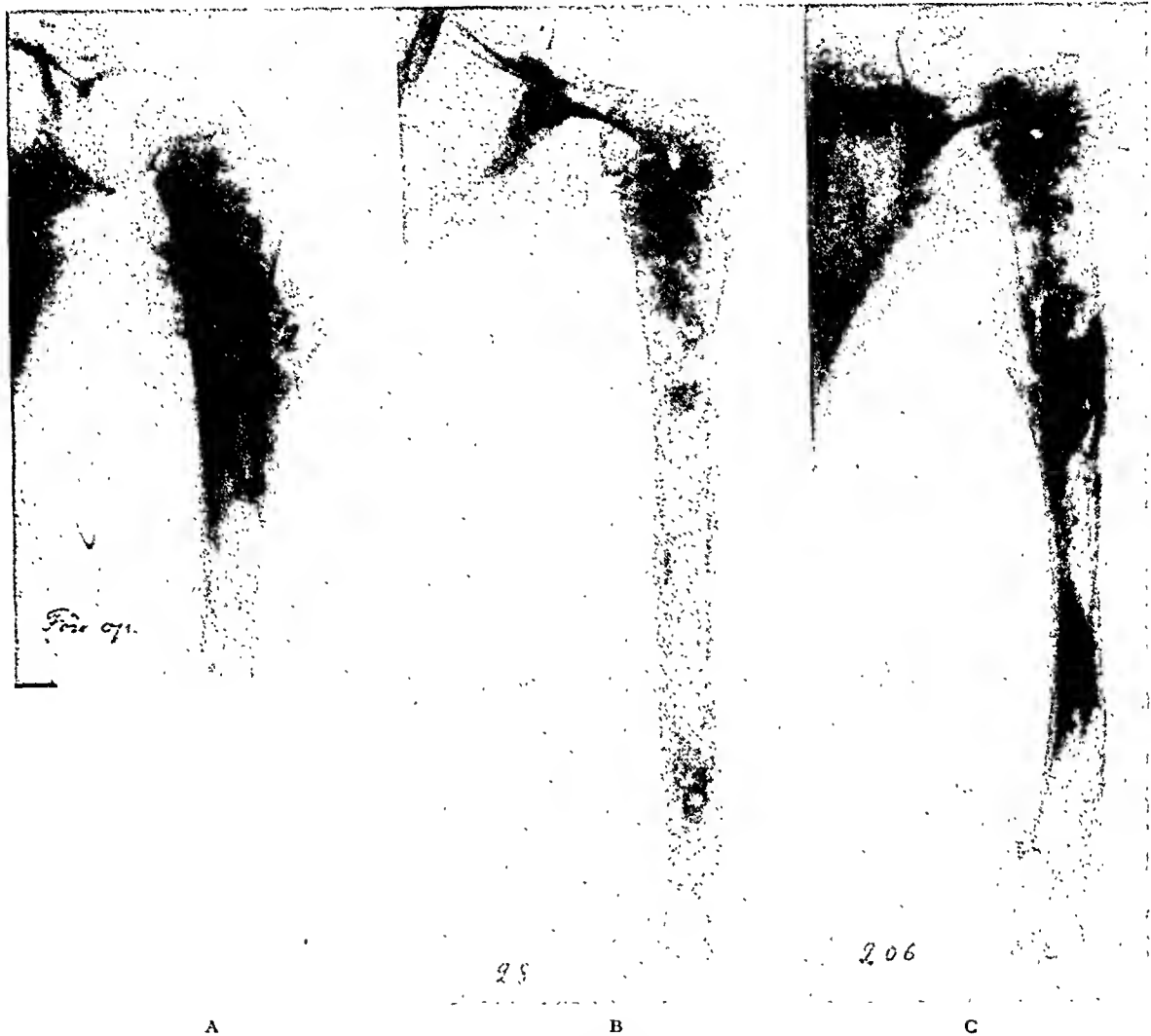
FIG. 1. Roentgenograms of the left upper arm (frontal views). A, before operation. B, twenty-eight days, and C, 206 days after operation. The last picture shows a fracture at the junction of the upper and middle thirds of the humerus.

was done by making multiple drill holes at the same level. By blunt subperiosteal dissection the proximal portion of the humerus was then freed up to the shoulder joint and removed. The upper third of the humerus was found to be enlarged by transparent, myxomatous masses which appeared to be quite well delimited. The bone was carefully cleared of these masses. Multiple holes were bored in the bone; and it was then boiled for ten or fifteen minutes in physiologic salt solution, and replanted with an os purum peg inserted in the distal end. The proximal end of the distal portion of the humerus was pushed onto the peg until a good position was obtained. (Fig. 1B.) The wound was closed without drainage. A fenestrated circular plaster cast was placed

osteogenic sarcoma was made by Dr. O. Reuterwall of Radiumhemmet, Stockholm.

By September 12, 1935, the region operated upon appeared satisfactory. The patient could move the shoulder joint slightly, no crepitation could be elicited, and the swelling had receded. The plaster cast was then cut to enable the patient to move the entire arm. On October 3, the plaster cast was discarded. The strength of the arm was very good, and the patient could raise it above the horizontal plane.

On October 24, the musculature of the left arm appeared the same as that of the right except for a somewhat atrophic deltoid muscle. The muscle was strong enough so that a dynamometer test showed: right 22 Kg., left

14 to 16 Kg. A roentgenogram of the chest showed a shadow at the base of the right lung, rather rounded and about the size of a hazel

FIG. 2. Roentgenogram of the left humerus after post-mortem excision.

nut. The general condition was good, however, and the patient had gained 10 Kg. in weight There were no local signs of recurrence.

At examination on December 29, the patient felt well, but the left upper arm was found to be greatly shortened. There was a fracture of the left humerus, (Fig. 1c), although the patient was not aware that he had broken his arm, and no pain was elicited either on palpation or on movement.

On January 28, 1936, the general condition was good. The sedimentation rate was 10 mm. in 1 hour. A roentgenogram showed that the pulmonary metastasis had increased in size. The patient's general condition then began to suffer and he started to lose weight. The sed-

imentation rate increased to 35 mm. The lung metastasis grew larger; the patient became increasingly troubled by cough, and on November 26, 1936 died quietly at home. The parents reported that during the last month of his life he had had increasing difficulty in breathing but no pain.

Autopsy was not permitted, but consent was obtained for the removal of the bone of the left upper arm. (Fig. 2.) The tissue around the bone was entirely healthy and no signs of local recurrence had appeared.

Histologically this tumor was of an unusual type. A piece of the tumor tissue removed at operation from the surface of the humerus for histologic examination showed a peculiar type of myxomatous, chondro- and osteogenic sarcoma. (Fig. 3.) Wide vessels, occasionally arranged in hemangioma-like nodules, were found in the tumor tissue. (Fig. 4.) The borderline between the tumor and normal tissue could be studied in a few places, and no invasive growth was found. The margin showed only connective tissue, poor in cells. The relation between this tumor and its surroundings was, therefore, not that of an ordinary sarcoma.

In the post-mortem specimen, a few islands of tumor tissue were found in the humerus, but these islands appeared to be dead. No homogeneous tumor mass was found. The absence of local recurrence was most likely due to the unusually good delimitation of the tumor. It appeared that the greater part of the original tumor must have been located on the surface of the humerus, and for this reason I feel that it is most correct to speak of it as a periosteal sarcoma. It is unfortunate that we were unable to examine the histologic structure of the metastasis in the lung.

It appeared, also, from the microscopic section of the post-mortem specimen that the bone formation around the replanted humerus was scanty. Despite the slow resorption, the fracture probably occurred because the bone was weakened through the multiple perforations. The implantation of os purum would perhaps have given better results, with respect to both bone formation and structural strength.

CONCLUSIONS

It is hardly possible to draw any conclusions from this case regarding the

value of the method for the treatment of osteogenic sarcoma. However, it is clear that operation should be performed as early as possible. In this case, two months were

This case is primarily of theoretical interest. It shows that it is possible to re-plant tumor-containing, boiled autoplastic material and obtain primary healing.

Fig. 3. Osteogenic sarcoma with wide vessels. Photomicrograph of the tumor obtained at operation. (× 180.) Hematoxylin-eosin stain.
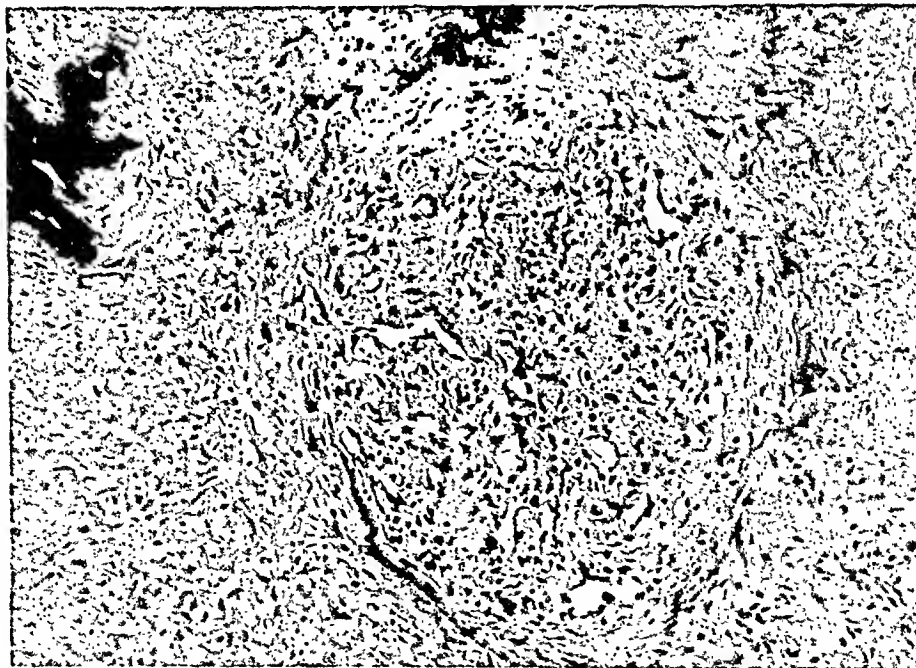
Fig. 4. Angioma-like nodule in the tumor tissue removed at operation. Hematoxylin-eosin and van Giesen stain.

lost in pre-operative Roentgen therapy which, in the light of later developments, was probably unfortunate.

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SIMULTANEOUS RUPTURE OF A PRIMARY OVARIAN PREGNANCY AND AN OVARIAN CYST

HEMORRHAGE FROM EACH OVARY—REPORT OF CASE

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OVARIAN pregnancy, while rare, does occur and has been reported occasionally in the literature. "Primary ovarian pregnancy," according to R. M. Mayne, is termed, "that type of gestation which takes place in the structure of the ovary, the fertilization of the ovum before its liberation from the Graafian follicle, with subsequent development of the embryo entirely within the substance of the ovary. . . . ovarian pregnancy may take one of several courses. Full term pregnancy with the living fetus after operation has been reported in the literature. The most usual course is an early ovarian abortion. This is followed by slight or severe intraperitoneal hemorrhage. The embryo is rarely found in these ovarian abortions, but chorionic villi are."

The case herewith mentioned is most rare and very interesting due to the fact that in the same patient we encountered the rupture of an ovarian pregnancy on one side and an ovarian cyst on the other side with bleeding from each ovary.

CASE REPORT

Mrs. G. C., white, female, aged 27 years, weighing 180 pounds, had had no previous illness nor operation. She was married and had two children, 7 and 2 years of age, and denied abortions.

Her menses had started at the age of 11 years, were regular in occurrence and of the twenty-eight day type. Her periods were six or seven days in duration and without pain. The last menstrual period had occurred on time (May 12, 1937), two weeks before her admission to the hospital, and had been of normal length.

On May 26, 1937, at about 1:00 a.m., immediately following coitus the patient experienced a sharp pain in her abdomen, which caused her to become faint. The pain continued on and off throughout the entire morning and all that day. I saw the patient in consultation at about 6:00 p.m. eighteen hours after the first attack of pain. She had already been seen by her family physician who had diagnosed the case as appendicitis. The patient said that she had vomited and had taken two enemas with no let up of the abdominal pain. Excruciating pain was also present in area of right shoulder blade.

The abdomen revealed marked tenderness and rigidity; the rigidity was most marked on the right side and peritoneal rebound was present. A blood count in the afternoon showed 3,500,000 red cells, with a hemoglobin of 70 per cent. There were 16,400 white cells of which 80 per cent were polymorphonuclears, and 10 bands were present. Immediate hospitalization was ordered.

Examination at the hospital revealed the following abnormal findings: the heart and pulse rate were 120 per minute. Tenderness and rigidity were marked throughout the entire abdomen, and there was also marked peritoneal rebound. All these findings were more pronounced in the right lower quadrant. The urinary findings were negative. Bulging and tenderness were present in both vaginal fornices and also rectally. The blood count at this time showed 2,900,000 red cells, with a hemoglobin of 60 per cent. White cells numbered 16,400, with 87 per cent polymorphonuclears.

Ruptured Graafian follicle with intra-abdominal hemorrhage was the writer's diagnosis preoperatively.

At operation, a subumbilical midline incision was made to and through the peritoneum. The abdomen was found full of free blood and blood clots. The right ovary was enlarged to the size of a walnut with a bleeding hemorrhagic area in the center. The left ovary was also enlarged and bleeding, but its size could not be determined because it was edematous and

entirely open, with the appearance of a blow-out in a rubber balloon. The uterus was slightly enlarged, freely movable, located in an anterior position, not ruptured or punctured. Both tubes appeared normal. The appendix and other viscera were not examined. Free blood in the amount of 750 c.c. was syphoned from the abdomen, and an unknown quantity was soaked up in lap pads.

Due to the age of the patient (27 years) I hemisected each ovary, removing the hemorrhagic mass in the right ovary and the edematous cystic part of the left ovary, controlled the bleeding in each, and closed the abdomen in layers, without drainage. The specimens were sent to the laboratory. 600 c.c. of whole blood were given by direct method. The operation was performed under gas-oxygen-ether anesthesia in forty-five minutes, with the patient in Trendelenberg position throughout the operation and for the next forty-eight hours. The pulse rate at the close of the operation was 120 per minute, with the blood pressure at 115/50.

Postoperative Care. Nothing was given by mouth for the first twenty-four hours. Morphine sulphate was administered every four hours. Catheterization was performed every ten hours. Saline solution, 3,000 c.c., every twenty-four hours was given. On the second day after operation, the hemoglobin was 52 per cent and the red cells 2,560,000 in number. Other measures included iron and ammonium citrate, whiskey, and a light diet after the fourth day. The temperature ran up to 102, with the pulse at 120 per minute during the first forty-eight hours, but from the fifth day until the time of discharge, the temperature and pulse rate remained normal.

All the sutures were removed on the ninth day. The wound remained clean throughout, and the patient was out of bed on the tenth day. At no time was the abdomen distended. The blood pressure at all times remained about 115/50, and on the ninth day stayed at 100/50. The patient was discharged from the hospital on June 8, 1937, having completely recovered except for a secondary anemia.

The pathologic diagnosis was: ruptured right ovarian follicular cyst with pregnancy; ruptured left ovarian cyst; intra-abdominal hemorrhage.

Pathologic Report. Dr. William Hala, Pathologist at the hospital, presented the following report:

"*Gross description:* Specimen consists of both ovaries, one collapsed, other showing a ruptured hemorrhagic cyst.

"*Histologic:* Section of smaller ovarian cyst, which was collapsed when received, shows a single follicular type of cystoma. Examination of larger ovarian cyst grossly shows a ruptured hemorrhagic area disclosing the presence of an ectopic gestation, without doubt primary in the ovary. There is first a lining of trophoblasts in the cyst wall. The contents of the cyst consist of coagulated blood and numerous well developed chorionic villi. Elsewhere this ovary shows the presence of single follicular cysts."

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SUPPURATIVE PERICARDITIS

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Introduction. Suppurative pericarditis is much more common than is ordinarily thought. Most cases, however, are found

FIG. 1. Shows the tremendous enlargement of the heart shadow. Note the unusual persistence of the pericardio-phrenic angle on the right side.

as a complication to pneumonia, and are usually discovered at autopsy. Since cases clinically diagnosed and successfully treated are comparatively rare even yet, I presume to report this case. Another reason is to outline and emphasize certain factors, and particularly to recommend a surgical approach which, although it is not new, has not generally been adopted.

Treatment of purulent pericarditis is necessarily surgical. It is permissible to aspirate for diagnostic purposes and possibly for palliative treatment.

Technique of Aspiration. It may be noted that when the pericardium fills with pus the heart "floats" forward; therefore a needle, when introduced, may easily enter the heart muscle or may damage one of the coronary vessels. Aspiration is sometimes done to the right of the sternum and in this area the needle might even tear the thin auricular wall

of the right auricle. When aspiration is necessary, it is the writer's belief that the fifth interspace in the midclavicular line

FIG. 2. The cardiac shadow is much reduced in comparison with Figure 1.

is the safest. The needle is directed upwards and slightly outwards to keep the point from approaching the heart itself. It is quite obvious that this method could not possibly drain adequately the posterior part of the pericardium, known as the oblique sinus.

Difficulties of Draining the Pericardium. Drainage of the pericardium usually is accomplished by resecting a portion of the costal cartilages of the fourth or fifth ribs near the sternum, opening the pericardium and inserting a rubber tube or Penrose drain. This obviously gives inefficient drainage, since adhesions form readily and, as pointed out above, the heart rides forward against the anterior pericardial wall. It is rather a far cry to the large dependent sac behind the heart called the oblique sinus, which is difficult or impossible to drain in this way. A more rational method of drainage is reported in the following:

CASE REPORT

The patient, a young boy aged 5 years, (#2530) had been healthy with the exception of whooping cough fourteen months previous.

350 c.c., was removed by aspiration. This pus had the consistency and approximately the color of milk or very thin cream. Cultures were taken. The child immediately was relieved.
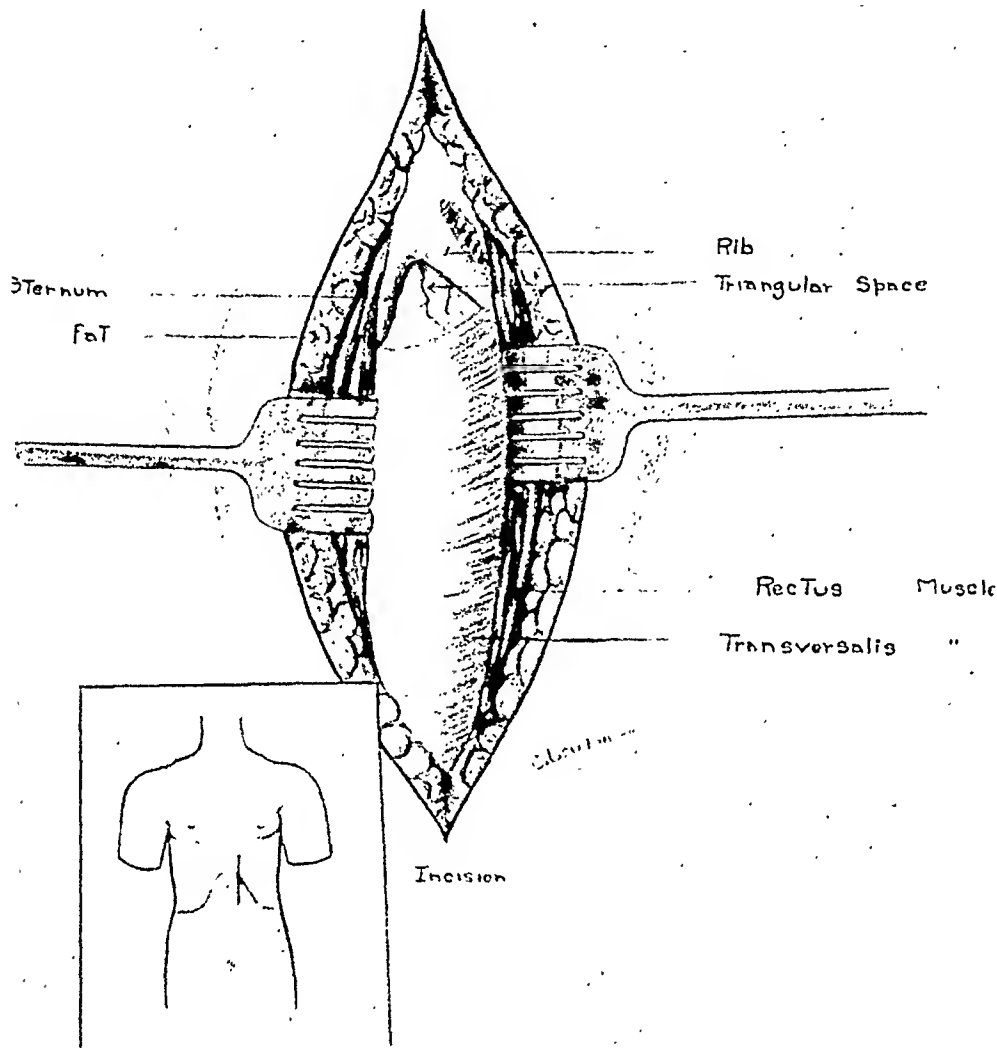
FIG. 3. The small figure shows the incision. The larger figure shows the incision retracted to disclose the anatomy involved. The ends of the costal cartilages may be removed if additional space is required.

The present illness had begun twelve days before with sore throat and a generalized malaise, resembling influenza. The child became very short of breath and somewhat cyanosed and had to be propped up to get his breath. The attending physician stated that for four days he had heard a rub which he thought was pericardial.

The patient was sent to the Queen of Angels Hospital. An x-ray picture showed a shadow which was obviously the heart, but because the pericardiophrenic angle was not obliterated, it was thought at first that it might be a very large heart. (Fig. 1.) However, the needle was inserted in the fifth space, midclavicular line on the left side, and a large quantity of pus, about

Aspiration was repeated on the following day, getting the same large quantity of fluid. On the third day the boy was operated on.

Operation. Local infiltration of 1 per cent novocaine was the only anesthesia used.

The incision was about 4 inches long through the costosternal angle, continuing up over the ribs about 1 inch and vertically downwards over the rectus muscle. The incision was carried through the anterior sheath of the rectus, and the rectus muscle was split and retracted. This exposed the posterior sheath of the rectus, made up of the transversalis, which is muscular in this particular place. (Fig. 3.) Continuing in the angle between the xiphoid process of the sternum and the costal cartilages, the finger

comes into a triangular space bounded by the sternal attachment of the diaphragm, the posterior sheath of the rectus and the costal at-

tinuous with the posterior sheath of the rectus. The finger may feel the pericardium, and if directed backwards and downwards, may feel
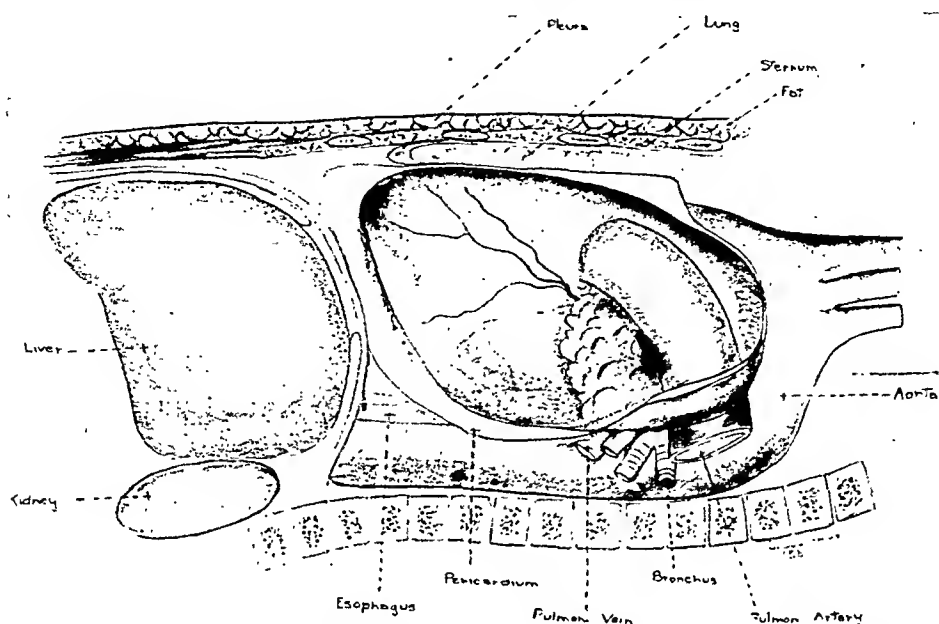
FIG. 4. Sagittal section (diagrammatic) to show how the pericardium comes to the surface in the triangular space.
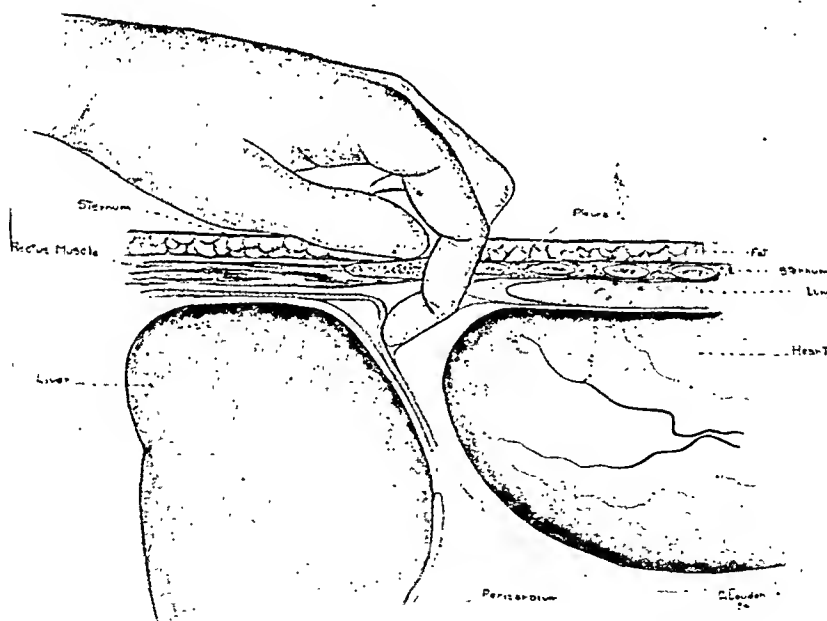
FIG. 5. The finger is inserted through the triangular space and hooked over the upper free border of the diaphragm, pressing on the pericardium.

tachment of the diaphragm. (Figs. 4 and 5.) Continuing up in this area, the finger passes over a rounded edge which represents the upper border of the diaphragm where it becomes con-

the upper free border of the diaphragm. It may be noted that upwards through this area is continuous with the anterior mediastinum which is not definitely walled off, the pleura

and lungs coming down on either side. The writer, therefore, did not open the pericardium at this stage but packed the area with gauze to promote adhesions in the anterior mediastinum. The gauze kept the wound open in the rectus, the lower part of which was sutured.

On the following day it was a simple procedure to remove the gauze and then open the pericardium. The finger was inserted to break down adhesions in the pericardial cavity, but in this case there did not appear to be any. A soft tube was guided into the pericardium and down posteriorly to the heart into the oblique sinus, with a stitch in the fascia to hold the tube in position. A large quantity of pus was evacuated.

The patient left the table in good condition. He was much improved; a second x-ray showed the pericardium to be smaller. (Fig. 2.) The tube was removed forty-eight hours after the operation, early removal being prompted by the fact that the tube was rubbed by the heart at each beat. The pericardium continued to drain well, the action of the heart apparently forcing the fluid out. On the second day the patient was placed on his face to allow the best possible postural drainage—this is considered to be a very important feature. Drainage gradually became less and ceased on the tenth postoperative day. Apparently no recurrence of fluid in the pericardium occurred and subsequent x-rays showed on enlargement of the heart. The patient did develop some dulness in the base of the left lung and some pleuritic effusion was present, but this absorbed without aspiration. Pulse and temperature came down to normal. The child returned home on the thirty-fifth day.

Follow-Up. The boy has done exceedingly well and is reported in excellent health two years later.

Bacteriology. The report of Dr. Roy W. Hammack is as follows: "Fluid examined is pericardial. General characteristics: large amount of thick green pus.

"Method of examination. Gram stain of the smear showed numerous pus cells and a few small Gram-negative bacilli. Cultures, June 20 and June 22, 1935, were made on Rosenow's blood and blood-agar plates. A growth of non-motile Gram-negative short, oval bacillus developed in the brain broth culture in twenty-four hours. No growth occurred on the blood agar plates.

"After transplanting several times in brain blood to which a small amount of sterile blood was added, a more luxuriant growth developed.

"Conclusion: no change in carbohydrate media. This organism has the appearance of B. pertussis."

SUMMARY

1. A case of purulent pericarditis successfully treated by operation is reported.

2. Emphasis is placed on the value of draining these patients by splitting the rectus muscle and approaching the pericardium from below, thus giving dependent drainage to the oblique sinus.

3. It is dangerous to try to treat these cases by repeated aspiration.

4. Early removal of the Penrose drain or tube from the pericardium is urged.

5. Emphasis is placed on the importance of postural drainage. It has been stated that these cases will drain well by postural drainage alone.

6. The author has described the anatomic relations which enter into this discussion.
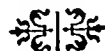
PARASAGITTAL MENINGIOMAS*

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IT is well known that the intracranial tumors which arise from the meninges are well circumscribed and can be completely removed. But it is also true that such a removal is not always accomplished easily. Because of their slow growth, meningiomas often attain considerable size without symptoms, they are frequently quite vascular, and in many instances they invade the dura mater and skull. With the possibility of a permanent cure of the disease in view, the surgeon has continued to work to overcome these obstacles and frequently is rewarded by a most satisfactory and lasting postoperative result. However, the tumors lying along the falx cerebri on either side of the mid-line—the so-called parasagittal meningiomas—through their very location present particularly difficult problems in diagnosis and in treatment. It is these problems which we wish to discuss briefly here.

CASE REPORTS

CASE I. M. C., white female, aged 59, reported a mass on the top of the head, progressively enlarging over a period of nine years, accompanied by convulsive seizures during the past seven months.

Present Illness. Nine years before admission the patient noticed a small lump on the top of her head. Her physician advised her that it was probably a cyst of the scalp which she should have removed if it enlarged. When she next consulted him the mass had enlarged to the size of a lemon and was obviously not an ordinary sebaceous cyst. During the seven months prior to admission the patient had had four or five attacks of Jacksonian epilepsy involving the right foot and leg.

Examination. The patient was a rather obese woman with mild cardiac enlargement,

a blood pressure of 170/80, and a mass measuring $6 \times 3 \times 1\frac{1}{2}$ inches near the vertex of her skull. She showed scattered neurologic signs, including a slight weakness of the right extremities, a slight left-sided ptosis, and a small left homonymous defect in her visual fields. The x-ray (Fig. 1) disclosed extensive changes in the vault of the skull, thought to be due to invasion by a meningioma or a cholesteatoma.

Operations. Biopsy showed the tumor to be a meningeal fibroblastoma. At the first stage operation the involved bone and a portion of the underlying tumor were removed by Dr. C. H. Frazier. (Fig. 2.) At the second stage (five months later) a meningeal fibroblastoma lying along the left side of the falx cerebri in the parietal region was extirpated by the author.

The patient had considerable right-sided weakness for a few weeks after operation. Several months later she had a few brief twitchings of the right foot, but was free of symptoms five months postoperatively.

Comment. The enormous extent of the bone involvement in this patient forced the removal of a large bone flap which left a correspondingly large skull defect. The suspected area was thoroughly coagulated with the electrosurgical unit, but it is impossible to say whether all cells were destroyed. In a woman of 60 it is doubtful whether the skull defect or a possible very slow recurrence would represent any real hazard, but obviously, either might be serious in a younger individual.

CASE II. M. P., white, female, 58, had a left occipital parasagittal meningioma which was removed in 1918, in 1930, and again in 1936. The bone was not involved, but invasion of the falx led to an incomplete extirpation on each occasion.

History. On her first admission in 1918 (at the age of 40) the patient's failing vision, headaches, staggering, and right homonymous

FIG. 1.

hemianopsia led to the diagnosis of a left occipital brain tumor. A left parasagittal meningioma 4 cm. in front of the pole of the occipital lobe was found and removed by Dr. C. H. Frazier. Symptoms of a recurrence began to appear ten years later and in 1930 a tumor measuring $7 \times 6.5 \times 5.5$ cm. was removed by Dr. Frazier. He noted the infiltration of the falx and feared a recurrence. The patient developed weakness of the right extremities, attacks of dizziness, impairment of memory and vision in 1935 (at the age of 58) and was operated upon for the third time in 1936 by the author.

Operation. A very large tumor principally on the left side of the falx but straddling its lower edge to extend across the midline was found, and a considerable portion extirpated.

Course. The patient's convalescence was uneventful after a rather stormy first twenty-four hours. Eight months later she was greatly improved mentally and in the strength of her right side, but was still slightly forgetful and had begun to drag her left leg slightly.

Comment. In this case the absence of bone involvement enabled the operators to replace the bone flap three times without risk, but the invasion of the dura led to recurrences in ten and five years respectively. Furthermore, the last recurrence was so extensive as to preclude the possibility of radical removal of the tumor.

CASE III. W. R., white, male, 27 (referred by Dr. William Anderson), had had a slowly enlarging "bump" near the vertex of the skull

FIG. 2.

for about one year. No neurologic findings were noted except early papilledema. At operation a bilateral frontoparietal parasagittal meningioma was removed with the portion of the falx and superior longitudinal sinus which it invaded. The involved bone was boiled and replaced.

History. For one year the patient had been aware of a slowly enlarging firm swelling near the vertex of his skull. (Fig. 3.) One month before admission he began to notice a momentary clouding of his vision when he changed his position quickly, as in getting up from a chair.

Examination. Neurologic examination was entirely negative with the exception of a swelling (apparently bony) about 2×3 inches along the midline of the head in the parietal regions, and bilateral papilledema. X-ray disclosed a thickening of an area in the parietal portion of the skull, showing a definite vertical striation.

Operation. A scalp flap was reflected around the bony swelling with the base to the right and posteriorly. The involved bone was surrounded by burr holes and excised. (Fig. 4.) Upon opening the dura it became apparent that the underlying tumor lay along both sides of the falx and involved this structure, the superior longitudinal sinus, and the overlying dura. After some consideration the sinus was ligated and cut anterior and posterior to the lesion and the tumor with all of the involved dura removed. (Fig. 5.) The bone flap was

boiled for ten minutes and replaced, being wired in place. The scalp was closed as usual.

Course. The patient made an uneventful recovery and was able to resume his duties as

FIG. 3.

a teacher when school opened two months after his operation.

DISCUSSION

The symptomatology of parasagittal meningiomas naturally varies with the position of the lesion along the falx and in general coincides with the symptom complex of the lobe involved—frontal, parietal, or occipital.

Two characteristics, however, seem worthy of emphasis. The first is the very early bone invasion when the tumor is near the surface; or, stated in another fashion, the frequent association of very extensive involvement of the skull with a relatively small intracranial tumor. In both Case I and Case III of this report, the operator was surprised at the comparatively small size of the tumors found beneath the very large bony swellings. A second characteristic which is perhaps in a large measure dependent upon the first, is the late appearance of neurologic symptoms or signs in case of meningiomas along the falx. In Case III, for example, no neurologic changes whatsoever could be detected though the

bony swelling had been present for one year and in spite of the fact that the tumor found at operation pressed upon the sensory and motor cortical areas bilaterally.
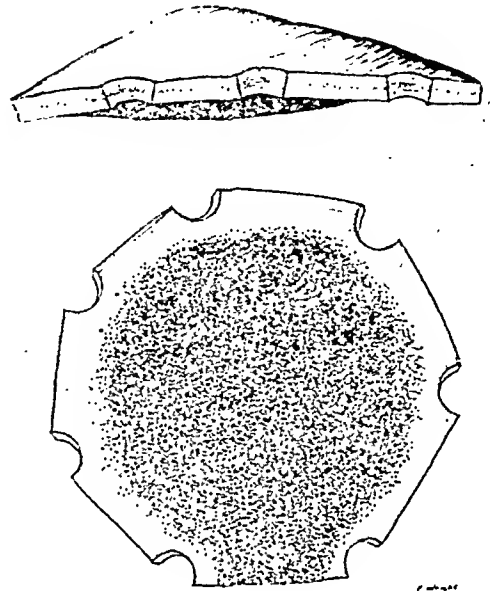
FIG. 4.

The remaining features of the symptomatology are essentially those of meningeal fibroblastomas in any location, namely: slow growth, often a history of convulsive attacks, and the late development of symptoms or signs of increased intracranial pressure. These need not be dwelt upon here.

The resection of a portion of the superior longitudinal sinus is a procedure which may be regarded as at least somewhat hazardous. Nevertheless, a number of reports in the literature[1,2,3] attest the fact that it can be carried out without producing any detectable change in the patient. As in the ligation of any large vessel, the sequelae of tying the longitudinal sinus seem to depend largely upon the adequacy of the collateral circulation. This in turn depends upon (1) the point at which resection is carried out, and (2) the existence of previous thrombosis from tumor invasion. It is generally agreed that such thrombosis is usually present in cases of

meningioma (although unfortunately there are no available histologic studies to prove it) and that in such cases any part of the sinus can be resected with impunity. If no such thrombosis exists, ligation of the anterior third can be done without fatality, but in some cases this has been followed by transient mental changes.

Boiling of portions of the skull to kill invading neoplastic cells or organisms was described by Naffziger[4] in 1936. He reported the successful use of the procedure in several cases of meningioma and osteomyelitis. In Case III this method was employed to avoid creating a large skull defect in a young male patient—a defect, moreover, which would have exposed a considerable part of both motor areas to possible injury.

eral inches of the superior longitudinal sinus, and a portion of the falx. The widely invaded overlying bone was resected,
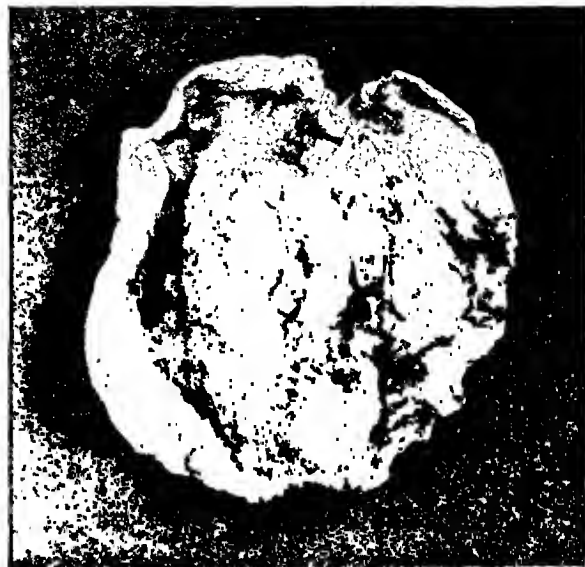
Fig. 5.

boiled, and replaced. This technique seems to offer a permanent cure without producing a postoperative skull defect.

SUMMARY

1. Three cases of successfully operated parasaggital meningioma are described. Their characteristics, (1) early involvement of overlying bone, and (2) the late development or total absence of neurologic symptoms, are stressed.

2. In one instance the very extensive bone involvement necessitated the creation of a large skull defect.

3. In a second the third recurrence of the tumor was found to be so large that only a partial removal could be effected.

4. In a recent case a complete extirpation of a bilateral parasaggital meningioma was carried out successfully by resection of all of the involved dura—including sev-

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CARCINOMA OF THE BREAST AND PREGNANCY

A REPORT OF THREE CASES

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THREE cases of carcinoma of the breast associated with pregnancy have occurred on the obstetrical service of the Long Island College Hospital during the past two years. One would ordinarily expect some effect of pregnancy on a neoplasm of the mammary gland, an organ which normally undergoes marked hyperplasia during pregnancy. A survey of the literature, however, shows a marked difference of opinion as to the effects of pregnancy on cancer of the breast. Presentation of these three cases may aid in formulating a more definite opinion.

CASE I. Miss S. I., a 34 year old white spinster, was admitted on May 8, 1930. She had first noticed a small lump in the right breast one year prior to admission. The tumor was excised by her physician during August 1929 and a course of x-ray therapy given.

Examination on admission showed a recurrent tumor mass beneath the old scar. A radical mastectomy was then performed. Pathologic examination revealed chronic interstitial mastitis and a duct cell carcinoma. The wound healed by primary union and she was discharged on the eighteenth day following operation.

The patient was readmitted on January 13, 1935, because of a recurrence in the other breast. This was first noted as a small, hard mass the size of which remained stationary for nearly two years and then increased. Examination showed a firm, immobile, nodular, oval mass in the left breast. An amputation of the left breast was performed after a preliminary course of twenty-six x-ray treatments were given. The pathologic diagnosis was alveolar carcinoma of duct origin. She was discharged on May 26, 1935, with the left breast wound healing by primary union.

The patient was again readmitted on December 10, 1935, when she stated that she had felt well and strong since her last admission and had gained in weight. The last menstrual period was during September 1935. At the beginning of December, the patient suffered vaginal bleeding and lower abdominal cramps which continued intermittently until the time of admission. A preoperative diagnosis of incomplete abortion was made and a curettage performed. The pathologic diagnosis was decidual endometritis and incomplete abortion. It was estimated that the patient was about three months pregnant.

During the two week period after her return home the patient's general condition rapidly became worse. She suffered from continued weakness and soon became bed-ridden. Examination revealed marked swelling of the abdomen, generalized jaundice, dehydration and dyspnea. She was readmitted at this time and died two days later. Post-mortem examination showed generalized carcinomatosis.

In the opinion of the attending physician who saw her from the onset and in all stages of her illness, the growth and spread of the tumor were markedly increased by the occurrence of the pregnancy.

CASE II. Mrs. M. N., 42 years of age, gravida v, para iv, was admitted on June 29, 1937, for recurrent carcinoma of the breast and pregnancy. Six years previously the patient had noticed a small lump in her right breast. Two years later she gave birth to her fourth child and failed to observe any change in the tumor during pregnancy or lactation. In 1934, the tumor became larger and a radical mastectomy was done. This was followed by six x-ray treatments and the application of radium. Her condition was surprisingly good up to the third month of the present pregnancy, at which time she came under our observation. Within the next few months, the patient grew rapidly worse, suffered from a persistent cough and lost 33 pounds.

On admission, she was emaciated and cyanotic. The veins of the neck and face were distended and three recurrent carcinomatous

ulcers were observed at the site of the old mastectomy scar. X-ray examination revealed a moderate amount of fluid in the pleural cavities. The uterus was the size of a six months' pregnancy and the fetal heart was heard distinctly. X-ray therapy according to the Coutard technique was given. The patient is still pregnant and expects to be confined within a short time.*

The attending physician, who has followed this patient from the onset of her illness, states that a marked change for the worse was noted in the patient soon after the beginning of her present pregnancy. This is contrary to the observation made in the course of her pregnancy four years previously, at which time little change in the tumor was noted. This case, however, may represent an instance of carcinomatous change in a fibroadenoma.

CASE III. Mrs. F. C., a 35 year old Puerto Rican, para III, was admitted to the prenatal clinic on August 30, 1935. She was about six months pregnant. Physical examination of the breast was negative save for the usual signs of pregnancy. She was admitted to the hospital on January 7, 1936, and delivered spontaneously a normal full term infant. At this time, two large tumor masses were palpated in the left breast. Two weeks later, one of these was excised. Histologic examination revealed the tumor to be an extremely malignant and rapidly growing medullary carcinoma. The patient refused permission for a radical mastectomy and left the hospital against advice.

She was readmitted on October 22, 1936. During the interim of nine months, she had lost considerable weight, had aged considerably, and became too weak to perform her ordinary household duties. The tumor mass left in the breast had become very extensive. On October 28, 1936, a radical mastectomy was performed. The pathologic examination revealed essentially the same type of tumor as noted previously. She was discharged from the hospital on November 18, 1936, and is at the present time receiving a course of x-ray therapy. Examination recently showed improvement in her general condition and a recurrence of the tumor at the site of the operation.

This case is an instance of rapidly growing cancer of the breast associated with pregnancy.

* This patient has since carried to term and delivered an infant spontaneously. She died within one week post-partum. The child is alive.

While it is conceivable that a small tumor may have been present at the time the patient first visited the prenatal clinic, it is hardly likely that a tumor of any large size would be missed. However, on admission to the hospital four months later, examination showed two large tumors. Her refusal to permit a radical mastectomy after one of the tumors was excised for diagnosis gave us a good opportunity to observe its rapid growth. The recent general improvement of the patient may be ascribed not only to the treatment but possibly to the fact that there is no longer the influence of pregnancy or lactation.

It was formerly universally agreed that pregnancy has a stimulating effect on all tumor growth and especially on the growth of mammary carcinoma. Reference to the literature demonstrates many case reports where it appears unquestioned that pregnancy and lactation stimulated the growth of the neoplasm and were responsible for early fatalities. In some instances, the patient survived only a few months after a small tumor was palpated.[1,2,3] These authors believed that the abundant vascular and lymphatic circulation of the breast during pregnancy and lactation offered peculiarly widespread channels for extension. While it is also suggestive that direct hormonal stimulation of the growth of the cancer occurs in the same manner in which normal mammary gland cells proliferate during the premenstrual phase of the sexual cycle and during pregnancy, there is no direct evidence for this belief. According to Loeb,[4] mammary gland cells that have undergone definite carcinomatous transformation are no longer responsive to normal hormonal stimulation.

On the other hand, one of the larger series of cases presents a number of five years survivals that corresponds very closely with that of the nonpregnant group.[5] It must also be remembered that in the age group in which pregnancy usually occurs, namely the young, cancer of the breast has generally been regarded as having a notoriously bad prognosis.

PARAGEUSIA AS A SYMPTOM OF KIDNEY DISEASE*

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OF the many symptoms which a patient may present, perhaps none is more baffling than that of disturbance of taste. It has been noted as an accompanying symptom of a number of disease syndromes.

Wildner[1] noted a frequent association of taste disturbance in gastrointestinal and biliary disorders, and in diabetes, and he reported its occurrence in a case of pancreatic abscess. Stout[2] reported an association of parageusia with calculus of the submaxillary gland. Barnes[3] reported parageusia in a patient with a chronic otitis media, which was relieved after a mastoid operation. Brain tumors and diseases of the nervous system have been noted as causes of parageusia, and in local diseases within the mouth, pyorrhea, heavy metal poisoning, and the like, disturbance of taste is not uncommon.

A number of texts on diagnosis and urology do not list disturbances of taste or parageusia in their indexes, and French,[4] while he gives a good discussion of the symptom, makes no mention of it in association with urinary tract disease. Reilly,[5] however, reported a case in which parageusia occurred within an hour after the onset of kidney colic, and he noted parageusia so frequently in association with hypertension that he wrote, " · . . . close questioning of all patients with high arterial tension and other evidences of nephritis has practically always revealed the presence of the symptom of persistent bad taste."

In most instances parageusia occurs in association with other symptoms, or some fairly evident pathology, but when it is the patient's sole complaint, the diagnosis is apt to be quite obscure, as the following protocol illustrates.

CASE REPORT

On December 26, 1934, after a year of migratory, rheumatic pains in shoulders, knees and chest, J. M., 58, male, teacher, had his chronically infected tonsils removed under local anesthesia. There was some post-operative bleeding the afternoon of the operation, but recovery was otherwise uneventful.

On March 14, 1935, the patient came to the office with a complaint of a peculiar taste, insidious in onset, and of about six weeks' duration, which he thought came from the back of his mouth, and from the left side more than the right. It was described as a sweetish-sour, metallic taste, resembling that of sheep-sorrel (Rumex Acetosella), a plant he had chewed during his boyhood on the farm. It had no relation to meals, nor to any particular foods. The patient felt that the taste was related in some way to the tonsillectomy as it had never been present prior to the operation.

Examination of the nose, ears, and mouth, including palpation of the salivary glands and probing of the left parotid duct, failed to account for the symptom. A careful history and physical examination revealed nothing of pathologic interest except a slight elevation of the blood pressure which was 154/90.

A variety of gargles and chewing gums was tried without improvement or notable relief. A dental consultant had nothing to suggest. After six months, on September 10, 1935, the patient reported that his unpleasant taste was still present, although he felt well otherwise.

On January 9, 1936, the patient was seen at his home. He complained of abdominal pain accompanied by marked distention, but there was no localized tenderness. Treatment was symptomatic and the patient promptly recovered. On March 9, the patient had a somewhat similar attack, in which there was an aching pain and some tenderness in the left lumbar area. A specimen of urine showed neither albumin nor sugar, while microscopic analysis disclosed 10 to 15 W.B.C. and a few epithelial cells.

A week later a flat x-ray picture showed an opacity about 1 cm. in diameter in the left kidney area. The patient was quite comfortable and continued his teaching, with weekly check-ups of the urinary findings. On March 20, there were 30 to 40 R.B.C. per high power field, but this decreased to 10 to 15 R.B.C. per high power field by May 11, 1936.

Cystoscopy was done May 16, 1936. A 6 F. catheter was easily passed up the right ureter; the collected specimen was negative, and phenolsulphonephthalein excretion was 12 per cent. A 5 F. catheter stuck in the left ureter about 5 cm. above the ureteral orifice; a collected specimen showed an occasional cell, and phenolsulphonephthalein excretion was only 10 per cent. A right pyelogram was essentially normal, but on the left there was a shadow (stone) in the kidney pelvis, deformity of the upper calyx, suggesting a tumor, and hydro-ureter above the point of constriction. There was no reaction to the cystoscopy and the patient returned to work. Parageusia was present during this entire period.

On June 13, 1936, an operation was performed under spinal anesthesia. A thin-walled solitary cyst (congenital) about 4 inches in diameter and containing serous, straw-colored fluid was removed from the upper pole of the kidney. The stone was removed from the kidney pelvis and the wound closed with drainage.

The post-operative course in the hospital was quite smooth, but the urine was loaded with pus. This was decreasing in amount under urinary antiseptics and the patient had returned home, when he developed an acute right epididymitis with chills and fever. Under conservative treatment this condition gradually improved, and, at the same time, the bitter taste disappeared. On October 22, 1936, the patient was feeling well, his urine was free from pus, and he had gained 8 pounds. Subsequent specimens were examined at intervals and were negative.

The patient had a chill on May 19, 1937, following an upper respiratory infection of several days duration. He volunteered the statement that the bitter taste, which he had not noted for six months, had returned. A urine specimen was loaded with pus. On urinary antiseptics recovery was prompt. Cystoscopy was repeated June 19, 1937. The left pyelogram was essentially normal and a 9 F. catheter was passed up the left ureter without difficulty. Both ureteral specimens were essentially negative. Parageusia was no longer present.

Here, then, is a patient who developed parageusia about one year prior to the onset of symptoms which led to the investigation of the urinary tract. Correction of the pathology relieved the parageusia, but six months later, following an upper respiratory infection and the flare-up of a pyelitis, the parageusia returned, to disappear again, as the pyelitis itself subsided.

It seems evident that there was a relationship between the urinary tract pathology and the parageusia. The mechanism, however, is not clear. There could be, perhaps, a direct renal-gustatory reflex. Or, one can postulate the absorption of an unsavory substance from the kidney to the blood stream, which is conveyed to the taste buds directly, or by secretion into the saliva. A central stimulation of the taste buds does not seem so probable. It is not unlikely, however, that the real mechanism depends on the reflex gastrointestinal disturbance so frequently seen in urinary tract disease, and that stimulation of the taste sense is due to regurgitation of gastric content. Alvarez[6] has shown that regurgitation from the stomach to the back of the tongue is not uncommon, and such a mechanism would seem to explain the relationship in this case.

CONCLUSION

Disturbance of taste may be an early and single symptom of urinary tract disease, and in the absence of other evident cause, patients presenting a complaint of parageusia should have a painstaking examination of the urinary tract.

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HYDRONEPHROSIS IN CHILDREN: REPORT OF TWO CASES*†

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INTRODUCTION

CONGENITAL ureteral obstruction is not uncommon in children. In a study of 2,420 pediatric cases coming to autopsy at Bellevue Hospital, Campbell[1] found ureteral blockage in approximately 2 per cent. Congenital ureteral obstruction may occur without urinary symptoms or findings, but persistent pyuria is the usual finding.

Early and proper relief of these obstructive conditions would prevent much renal damage and increase the life span of many children. The necessity of closer cooperation between the pediatrician and the urologist is obvious.

Two cases of hydronephrosis due to congenital ureteral obstruction are presented here, both of which are on the Pediatric Service of the New York Hospital and have been seen in consultation by the Department of Urology (James Buchanan Brady Foundation) of the Hospital.

REPORT OF CASES

J. C., a white male, was first seen in the New York Hospital on February 4, 1934, at the age of two months, at which time he was suffering from hematuria, dysuria, and urinary frequency of twelve hours' duration. The past history was unimportant.

Physical examination showed a well-developed, well-nourished infant who appeared acutely ill. The abdomen was distended and the left kidney large and easily palpated. The right could not be felt. The external genitalia were normal except for a phimosis.

Laboratory examination showed the urine to be cloudy and loaded with pus with specific

gravity of 1.010, neutral reaction, and albumin 2+. The blood urea nitrogen was 38 mg. per 100 c.c., and the phenolsulphonephthalein out-
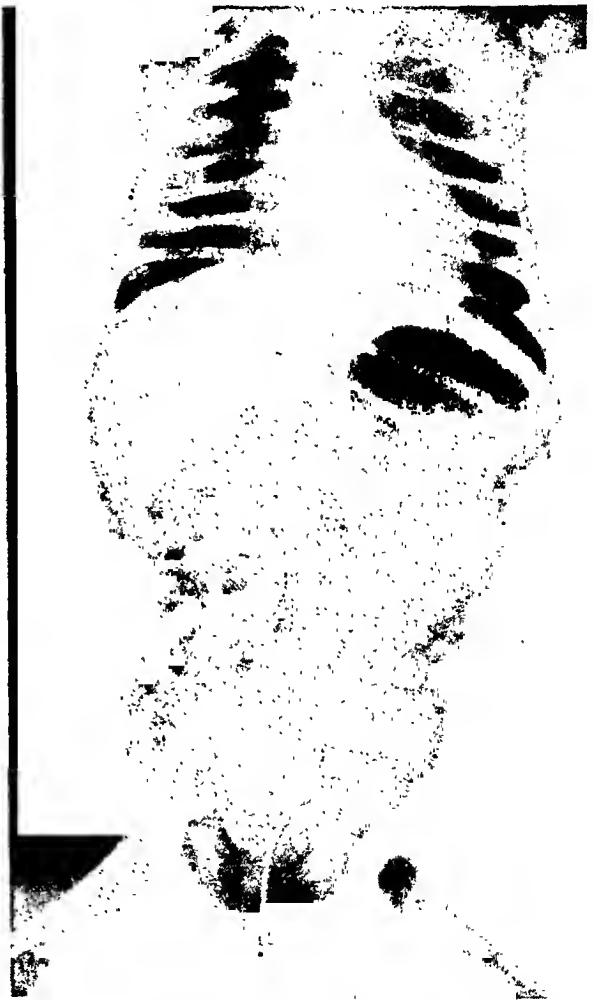
FIG. 1. Retrograde pyelogram showing hypoplastic right kidney and dilated ureter.

put 5 per cent in one and one-half hours, with a total of 30 per cent in three hours.

Cystoscopy disclosed a pale bladder mucosa, the ureteral orifices in normal position, and constriction of the vesical neck. Pyelography revealed a hypoplastic right kidney with a somewhat dilated ureter and a markedly hydronephrotic left kidney with a tortuous hydro-ureter. Ten-minute phenolsulphone-

[1] CAMPBELL, M. F. Ureteral Obstruction in Infancy, *Am. J. Surg.* 5: 445, 1928.

phthalein excretion on the right side was 1 per cent and on the left 8 per cent. (Fig. 1.)

A left nephrostomy was recommended.

condition improved and he was discharged to return for further treatment.

Six weeks later he was again admitted to the
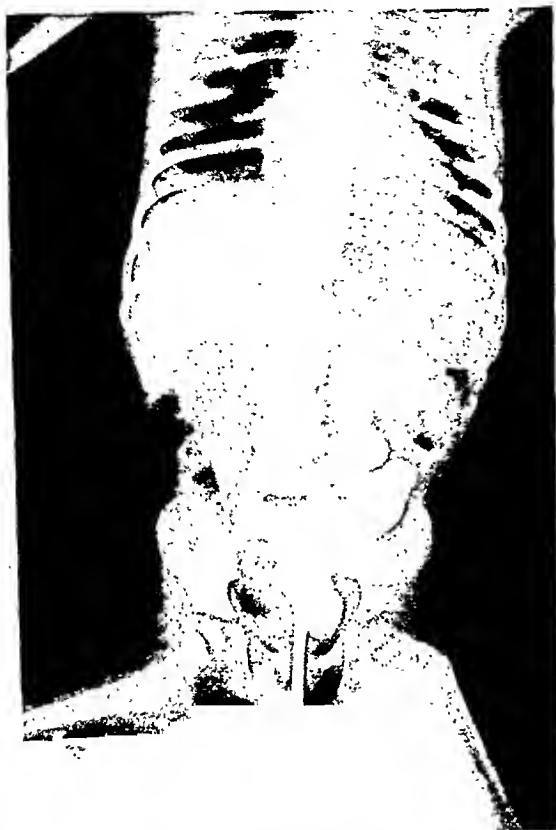
FIG. 2. Left hydronephrosis and hydroureter, with strictures at the ureteropelvic and ureterovesical junctions.

FIG. 3. Hypoplastic right kidney. Left hydronephrosis and hydroureter, with strictures at the ureteropelvic and ureterovesical junctions.

The patient improved under medical treatment, and was discharged eleven weeks after admission.

He was readmitted twenty-six months later because of a reaction following vaccination for smallpox. There had been no urinary symptoms in the interim, but urinalysis showed a trace of albumin, many granular and cellular casts, and many pus cells. The blood urea nitrogen was 25 mg. per 100 c.c. Cystoscopy revealed a normal bladder. Catheterization of the right ureter could not be accomplished, but the left ureter was readily catheterized. Bacilli coli were obtained by culture from the urine of the left kidney. Pyelography showed increased dilatation of the renal pelvis and ureter, with strictures at the uretero-pelvic and uretero-vesical junctions. (Fig. 2.)

The left ureter was drained for six days by means of a No. 5 French catheter. The child's

hospital. The dysuria and frequency had continued since his previous discharge, but the urine showed less pus than on the earlier admissions. The blood urea nitrogen was 17 mg. per 100 c.c.

Cystoscopy was again done; a No. 5 French ureteral catheter was placed in the left ureter for drainage and allowed to remain in position for five days. The child was then given a ketogenic diet for two weeks, during which time the pH of the urine remained about 5.6. Under this treatment his urinary symptoms improved, and he was discharged, to return in a month.

Five weeks later (Sept. 14, 1936) he was readmitted to the hospital because of intermittent attacks of chills and fever, associated with malaise, over a period of two weeks. Examination at this time showed the urine to be cloudy, with a specific gravity of 1.010, and

15 to 30 white blood cells per high power field. Pyelography revealed no changes in the right kidney, but the left pyelogram showed more

Fig. 4. Cystogram showing left hydronephrosis, dilated and tortuous ureter, and distorted ureteropelvic junction. Large indefinite mass in right kidney region.

marked dilatation of the kidney and ureter than upon previous examinations, with strictures at the uretero-pelvic and uretero-vesical junctions. (Fig. 3.)

A left nephrostomy, with correction of the ureteropelvic stricture, has been advised.

A. R., a white female, aged 6 years, was admitted to the New York Hospital on July 17, 1936, complaining of enlargement of the abdomen, abdominal pain, and headaches.

For several months the patient's mother had noticed that the child's abdomen was becoming larger, although she was losing weight. She had become fretful and listless, and at times complained of headaches and slight pain in the mid-abdomen. At no time had there been any urinary symptoms. The past history was irrelevant.

Physical examination showed a pale, thin child, apparently chronically ill. The abdomen was asymmetrically enlarged, with a mass occupying the entire upper right quadrant and extending into the right flank. There was no tenderness of the mass, but it was fluctuant

and moved on respiration; it could be differentiated from the liver.

Laboratory findings were as follows: The urine

Fig. 5. Large hydronephrotic right kidney with destroyed cortex, and very narrow ureteropelvic junction.

was cloudy, with a specific gravity of 1.002; alkaline in reaction; showed albumin 2+; a few red blood cells and many white blood cells. The hemoglobin was 79 per cent; the red blood count 3,710,000; the white blood count 7,650; polymorphonuclear leucocytes 70 per cent; blood Wassermann negative. The blood urea nitrogen was 11 mg. per 100 c.c. and the blood sugar 92 mg. per 100 c.c. The total two-hour phenolsulphonephthalein excretion was 13 per cent.

Cystoscopy showed a normal urethra and moderate intrusion of the median portion of the vesical neck, with 20 c.c. of residual urine. The bladder mucosa appeared chronically inflamed; the ureteral orifices were in their normal position. The left ureter was catheterized, but the catheter failed to enter the renal pelvis. The right ureter could not be catheterized. Roentgenograms at this time showed a large left hydronephrosis, with a distorted ureteropelvic junction and a dilated and tortuous left

ureter. In the right kidney region was a large, indefinitely outlined mass. Intravenous urography revealed a functionless right kidney.

FIG. 6. Renal pelvis injected with opaque medium. Very thin cortex.

(Fig. 4.) Following the patient's admission to the hospital the right kidney rapidly increased in size, causing gastrointestinal and respiratory embarrassment.

mately 2,000 c.c. of clear straw-colored urine, was removed. The cortex was greatly thinned out, and there was a marked stricture at the uretero-pelvic junction, causing complete obstruction. (Figs. 5, 6, 7, and 8.)

Convalescence was uneventful, with persistent pyuria as the only urinary symptom. Cystoscopy was again performed and the left ureter catheterized without difficulty, but, as in previous attempts, the catheter failed to enter the pelvis of the kidney. A retrograde pyelogram showed poor filling of the kidney pelvis due to some uretero-pelvic obstruction. However, both the pelvis and ureter were considerably dilated. A culture of the urine from the left ureter showed *Bacillus subtilis.* The bladder was irrigated and the urethra dilated to No. 26 French. Further attempts to pass a catheter past the uretero-pelvic junction were unsuccessful. The blood urea nitrogen remained normal, but the urine continued to show a moderate amount of pus. (Fig. 9.)

Since the hydronephrosis was increasing, a left nephrostomy was done for drainage five weeks after removal of the right kidney. Investigation of the ureter showed it to be plastered onto the renal pelvis, forming an

FIG. 7. Photomicrograph × 130. Cross section of ureter at strictured area, showing thin wall and decrease in mucosa and muscularis.

Ten days after admission a right nephrectomy was done as an emergency measure, and a large hydronephrotic kidney, containing approxi-

S-shaped kink with a narrow uretero-pelvic junction. The ureter was freed of adhesions and dilated with a No. 12 French ureteral catheter

FIG. 8. Photomicrograph × 130. Cross section of ureter below strictured portion, showing a more normal wall.

FIG. 9. Marked left hydronephrosis and dilated ureter, with a stricture at the ureteropelvic junction.

FIG. 10. Pelvis of left kidney injected with opaque medium.

through an opening made in the renal pelvis. A nephrostomy tube was inserted from within the pelvis through the cortex at the lower pole, and a No. 12 French ureteral catheter was passed through the nephrostomy tube and down the ureter for a distance of 10 cm. The pelvis was closed tightly and the kidney replaced in its normal high position.

Convalescence following this procedure was uneventful, and the ureteral catheter was removed on the fifth postoperative day. No urine was passed through the urethra for the first ten days. Pyelograms following retrograde injection of an opaque medium into the ureter and kidney pelvis through the nephrostomy tube have failed to show any of the medium passing through the uretero-pelvic junction. (Fig. 10.) Attempts to dilate the uretero-pelvic junction from below have been unsuccessful, due to the tortuosity of the ureter. Although there has been a gradual increase in the amount of urine passed through the urethra, nephrostomy drainage is being maintained, in order to remove the burden of back pressure from the ureter and kidney. At no time has the urea nitrogen been above normal limits. The phenol-sulphonephthalein function has increased, and the patient's general condition has improved.

A plastic operation on the kidney pelvis at a later date, with correction of the vesical neck obstruction, has been advised.

SUMMARY

1. Two cases of congenital malformation of the urinary tract with hydronephrosis, occurring in children, are presented.

2. In the second case there was bilateral congenital stricture at the uretero-pelvic junction, but there were no urinary symptoms. Early diagnosis in this case would undoubtedly have prevented the loss of one kidney and extensive damage to the other.

3. The first case presents a hypoplastic right kidney and hydronephrosis of the left kidney, with strictures at the uretero-pelvic and uretero-vesical junctions. The function of the hypoplastic kidney is insufficient to maintain life; therefore, the function of the other kidney must be preserved by establishing drainage.

SULFANILAMIDE AND PRONTOSIL IN THE TREATMENT OF HEMOLYTIC STREPTOCOCCUS EMPYEMA IN CHILDREN*†

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THE use of sulfanilamide and its derivatives in the treatment of infections due to the hemolytic streptococcus has been accorded an enthusiastic reception by the medical profession in the short time that has elapsed since the report by Long and Bliss.[1] The dramatic results from this form of chemotherapy, which have been reported by numerous investigators, foster the idea that it will cure such infections unless they are of utmost severity. Empyema due to the hemolytic streptococcus would seem to be an ideal field for the action of drug because the long time during which the fluid remains thin and can be removed by aspiration gives ample opportunity for the medication to forestall surgery, if that is possible. Our experience in this connection on the Children's Surgical Service at Bellevue Hospital has, however, been somewhat different.

Between January 1, 1937 and September 1, 1937 we have operated on twenty-three cases of empyema of which four were due to hemolytic streptococcus. These four cases were first treated on the Pediatric Service (Dr. Charles Hendee Smith, Director), and all received sulfanilamide, or its derivative, prontosil. During this period there were in Bellevue Hospital no other cases of empyema in children primarily caused by the hemolytic streptococcus, although in two cases that organism was a secondary invader in an empyema originally due to pneumococcus.

CASE REPORTS

CASE I. G. C., white male, aged 10 weeks, was admitted to the Pediatric Service on March 3, 1937. Twenty-four days before this he had been in the hospital suffering from facial erysipelas for which he had been treated by prontosil. He had recovered promptly, but two weeks after discharge he developed cough and fever for which he was readmitted. On admission he had a well developed lobar pneumonia with pleural effusion. Aspiration of his chest yielded 200 c.c. of slightly cloudy fluid from which streptococcus hemolyticus was cultured. His temperature fluctuated between 104.4 degrees and normal for the first six days. On the sixth day 5 c.c. of prontosil was given intramuscularly three times, and thereafter twice a day. Meanwhile, the infant was put in an oxygen tent and given the standard treatment for pneumonia. There was no particular change in his course or temperature until the twelfth day when his temperature rose to 105 degrees and then dropped to normal by crisis. Meanwhile, since the baby had acquired a bright red color due to the prontosil, the drug was stopped for one day and then continued in 1 c.c. doses twice a day for eleven days. It was discontinued a week after the crisis as there was no longer any fever.

The fluid in the chest continued to accumulate and was aspirated about twice a week. It was almost clear at first, but soon became turbid and finally frankly purulent. In spite of this, the temperature remained normal after the crisis and on this account operation was deferred. However, the child's general condition became gradually worse, he developed a scoliosis, and, three weeks after the crisis, his chest

contained a considerable amount of pus which was too thick to run through the aspirating needle. Operation was now obviously necessary.

Under local anesthesia intercostal drainage with insertion of flapper tube was done thirty-two days after admission. Improvement commenced at once, but was slow. Except for the prolonged convalescence, the post-operative course was uneventful and the patient was discharged June 1, 1937 with wound healed and lung expanded.

CASE II. R. B., a five year-old boy, was admitted to the Pediatric Service March 20, 1937. On admission he had a temperature of 104 as a result of lobar pneumonia and pleural effusion. Aspiration of the chest produced a clear fluid from which hemolytic streptococcus was cultured. Prontosil, 5 c.c., was given every four hours for four days, after which sulfanilamide was given in doses of 5 gr. three times daily. The routine treatment for pneumonia was also given. The temperature dropped to 100 degrees and fluctuated between this and 102 for ten days. It then rose to 104 and fluctuated around this level for another week. During this time the child's chest was aspirated nine times. The fluid, which was relatively clear at first, became cloudy and eventually purulent. On April 9, twenty days after admission, a rib resection was done and a flapper tube inserted.

The temperature dropped to normal after operation and did not rise to any extent thereafter. The discharge continued to be profuse, and sulfanilamide was therefore started again on the twenty-sixth post-operative day. There was no immediate effect from this treatment, but by the end of three weeks the hemoglobin had dropped to 65 per cent and the red blood cells to 2,500,000. The medication was then discontinued although there was still considerable drainage. Eventually the drainage ceased, the wound closed and the patient was discharged June 24, 1937 with lung expanded.

CASE III. J. A., a two year-old boy, was admitted to the Pediatric Service March 8, 1937. He had been admitted to another hospital February 10, 1937 with pneumonia, and was subsequently transferred to Willard Parker Hospital as a diphtheria carrier. He developed bilateral acute otitis media during this time, and, when admitted to Bellevue from Willard Parker, had running ears on both sides and signs of consolidation in his chest. This was suspected of being fluid, but aspiration pro-

duced nothing. He was therefore treated for an unresolved pneumonia until it became evident that he had an encapsulated empyema. A second aspiration produced pus and rib resection was done at once. This opened an encapsulated, interlobar cavity, filled with pus and communicating with a bronchus. The cavity was packed with vaseline gauze. The immediate response to the operation was good, but on the second post-operative day the temperature went to 103. The packing was removed and replaced by a rubber tube allowing a large collection of pus to escape. On the same day the culture of pus taken at operation was reported as containing hemolytic streptococcus in pure culture. Sulfanilamide, 5 gr. every four hours, was ordered, but by the time the first dose was given the temperature was coming down, and before the second dose was given, had reached normal. It continued normal thereafter and the sulfanilamide was discontinued after two days, as it was thought the temperature fall was due to the reestablishment of drainage. The bronchial fistula closed spontaneously and the drain was removed twenty-three days after operation. Recovery was complete although the ears continued to drain for some time after discharge.

CASE IV. H. P., a boy of 18 months, was admitted to the Pediatric Service June 6, 1937. He had been in another hospital since May 4, 1937 where he was admitted with bilateral acute otitis media, draining spontaneously, and lobar pneumonia. The pneumonia showed signs of resolution after two weeks, but then fluid appeared. The chest was aspirated May 31. The fluid was said to contain acid-fast organisms, for which reason he was transferred to Bellevue with the diagnosis of tuberculous empyema. On admission to Bellevue he had bilateral running ears, signs of an extensive collection of fluid in his left chest and a temperature of 102. Three hundred and fifty c.c. of slightly cloudy fluid was aspirated, from which a pure culture of streptococcus hemolyticus was grown. Careful examination of this and subsequent aspirations did not disclose any acid-fast organisms and two tuberculin tests were negative, as a result of which we concluded that the admitting diagnosis was erroneous. The child was immediately put on the routine treatment for pneumonia, two blood transfusions were given, and sulfanilamide was started. As he could not be induced to take the medication, he was given prontosil instead in doses of 5 c.c. every six

hours. The temperature fluctuated about the admission level of 102 for a week and then at about 103 and 104 for another week. Thereafter it dropped to normal, only to rise again five days later to 103. On June 25, sulfanilamide was substituted for prontosil in the original dose and this time it was readily taken.

Meanwhile the patient was subjected to repeated thoracenteses. The fluid which was thin and slightly cloudy on admission, became frankly purulent on June 25 and was too thick to run through the needle July 1. Cultures of the pus continued to be positive for hemolytic streptococcus and the general condition of the patient was becoming steadily worse. He was a very sick child when he was transferred to the surgical side on July 3.

Intercostal drainage under local anesthesia was done the same day and a flapper tube inserted. Improvement started at once. The drainage, which was profuse after operation, diminished as the baby improved and by July 22 was so scant that the tube was removed although he still had a slight amount of discharge from the sinus. Four days later he was transferred to Willard Parker Hospital as a diphtheria carrier. Upon his return to Bellevue, August 3, he had evidence of a re-accumulation of fluid in his chest. The tube was inserted again but no pus was obtained. He continued to do poorly, however, and his ears, though still draining as a result of chronic mastoiditis, were not considered sufficient cause for his trouble. On August 11, rib resection was done and a pocket of pus drained. A blood transfusion was given after operation and the patient began to improve at once. One week later sulfanilamide was started again, 5 gr. three times a day, in an attempt to expedite his recovery. It was discontinued two weeks later because of two unexplained temperature rises to 104. Shortly after this the tube was removed and the patient made a satisfactory recovery.

COMMENT

Of the four cases here reported three had adequate and prolonged treatment with sulfanilamide, prontosil or both. In these three cases a determined effort was made to control the disease by chemotherapy and repeated aspirations, but in all cases it required surgery to effect a cure. In the fourth case sulfanilamide was used late, after surgery had put the patient on the road to recovery. Incidentally, this case had the shortest drainage time of the four and brought the average time from operation to final removal of drains to forty-five days instead of fifty-three days, the average of the three adequately treated cases. The other cases of empyema, in which organisms other than streptococcus hemolyticus caused the infections, averaged twenty-seven days of drainage.

On the other hand it is to be noted that none of the hemolytic streptococcus cases died, although three of them were very sick children, one of them only ten weeks old when admitted. Also, the temperature before operation was lower than would ordinarily be expected, a point to be remembered as it does not indicate resolution of the infection. Otherwise the course of the cases treated by chemotherapy was essentially that of the average case of hemolytic streptococcus empyema.

Sulfanilamide and its derivatives are useful drugs, but too much should not be expected of them. It is obviously unfair to draw conclusions from such a small series; however, we do call attention to the fact that in our hands hemolytic streptococcus empyema in children was not materially affected by chemotherapy and that adequate surgery is still necessary to effect a cure.

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MULTIPLE FIBROUS LOOSE BODIES OF THE SHOULDER JOINT*

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CASES of loose bodies in joints are frequently reported in the literature, but so large a number as 800 loose bodies in the shoulder joint is not often encountered. The case here reported which came under our observation and which was operated upon, may therefore be worthwhile reporting. This case may also give a clue to the etiology of a condition that gives rise to such a multitude of bodies.

REPORT OF CASE

A. K., a housewife, 37, born in Austria, was admitted to Fordham Hospital on November 15, 1935, complaining of painful swelling of the wrists, left shoulder, left knee, and left ankle. The onset had been gradual and dated back two years.

The patient was married and had three healthy children, the youngest ten years of age. Her menstrual history was normal, and there was no history of previous diseases. She denied any venereal infection.

Physical examination disclosed a fairly well developed, middle-aged woman, slightly anemic. Heart and lungs were normal and gynecologic examination showed no abnormality. The wrists were swollen, but not red. Flexion and extension were distinctly limited, and crepitus was present. The left wrist was quite painful. The fingers were swollen at the proximal interphalangeal joints as in ordinary proliferative arthritis. The left shoulder showed marked swelling covering the entire aspect of the joint, extending down to the attachment of the deltoid. It was boggy in consistency, and one could feel the presence of fluid, but there was no tenderness. Motion was only slightly limited to abduction and outward rotation, but marked crepitus was present. The left knee was swollen and slightly tender at the medial side, but motion was only slightly limited. Crepitus was present. The left ankle was also swollen, and showed some spasm on motion.

Laboratory Findings. The blood count was normal, as was the urine. The vaginal, cervical and urethral smears were negative, and the blood Wasserman also negative.

X-ray of the left knee showed all the characteristics of hypertrophic arthritis, distention of the suprapatellar bursa, but no decipherable loose bodies. In the left shoulder a large, irregular, soft mass could be seen, but no bony irregularity. The joint space was normal. (Fig. 1.)

The shoulder was aspirated and 60 c.c. of amber-colored cloudy fluid was withdrawn. This was examined for malignant cells and organisms, neither of which were found. Guinea pig inoculation likewise gave a negative result, while the culture of the aspirated fluid showed no growth. The fluid was also injected intradermally, but no local reaction or wheal appeared.

An exploratory operation of the left shoulder was done on December 13, 1935. A semicircular incision was made on the left shoulder, with the convexity extending downward to the lower portion of the deltoid. The deltoid muscle, was markedly atrophied, and upon its cleavage, a large soft mass was found, which gave the impression of adhesions between the capsule and the lower portion of the deltoid and the acromion process. It was hard to find any pedicle. A syringe was put into the mass, but after many attempts, only 10 c.c. of straw-colored fluid could be removed. As it was impossible to shell out the mass, the capsule was opened and many small white pleomorphic soft masses were found. The head of the humerus was easily visible. The synovial membrane was thickened, irregular, and covered with some villi, not attached to pedicles. The

head of the humerus showed degeneration of the cartilage and some parts were covered with pannus. The loose bodies were removed. The pathologist later reported finding 671, but considering those that were lost on the operating table, the total number of these bodies was more likely about 800 (Fig. 2), some of which had been situated in the posterior aspect of the joint. It was evident that the masses had been in the capsule proper. The synovial membrane was removed where it was irregular, and a part of the capsule was also removed both for examination and to allow tight closure. The capsule was sutured in two layers.

The wound healed by first intention. The pain and swelling disappeared, and within ten days, the patient was able to use the shoulder freely.

Another x-ray taken later showed a clearer aspect of the shoulder joint. (Fig. 3.)

The patient was then discharged with instructions to return to the out-patient department for baking. The joint became normal both in contour and in function within six weeks, at the end of which time x-ray showed a perfect joint with good bone structure. (Fig. 4.)

Our diagnosis was a probable osteochondromatosis.

Pathologic Report. The specimen was carefully examined by the pathologist, L. R. Ferraro, M.D., who was kind enough to give

FIG. 1. X-ray of the left shoulder before the operation.

us a detailed report for this publication. His statement was:

"*Gross:* Specimen consists of 671 joint bodies, ranging in size from a lentil to a small grape.
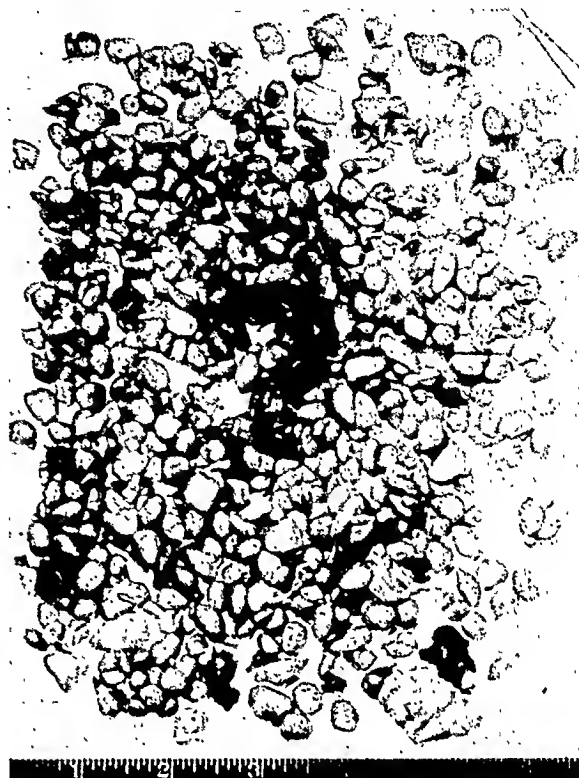
FIG. 2. The loose bodies removed from the shoulder joint.

The surfaces are smooth and glistening, with a greyish white color. They are of various shapes. Some are bean-shaped, others flattened; some are globular and a few are totally irregular. Cut section through many of these masses reveals an almost identical picture. This consists of a softer, translucent, pearly center and a thin cortical rim of denser white tissue. They all cut with little resistance; the cut surface resembles soft cartilage or coagulated albumin. Accompanying the specimen is a hemorrhagic fibrous capsule covered with a fibrinous exudate.

"*Microscopic:* Histologic sections were made from many of the joint bodies as well as from the pieces of capsule. The picture presented by the majority of the masses could be summarized as follows: The greater portion of the joint bodies consists of amorphous homogeneous pink-staining material in which a few scattered elliptical nuclei are noted. A number of small islands are also scattered throughout this area. These stain palely and occasionally present spindle-shaped nuclei. The periphery of the joint body contains definitely more cellular

elements. These consist of fibroblasts, lymphocytes and occasionally polynuclear cells. Small areas of nuclear débris are occasionally encountered.

FIG. 3. X-ray of the left shoulder taken five days after the operation.

second operation. X-ray of the knee showed ordinary findings of a degenerative arthritis, but no osteophytes.

FIG. 4. X-ray taken six weeks after operation, showing a normal joint.

countered. No cartilage or bone cells could be recognized in any of the sections.

"With azo-carmine stain, the greater portion of the body appears reddish in color, while at the periphery, irregular bands of collagenous bundles are noted. Sections through the capsule reveal dense areas of wavy collagenous bundles in which a number of small focal lymphocytic accumulations are found. The cellular reaction does not appear to be specific of any particular lesion. No synovial membrane could be recognized.

"*Diagnosis:* Multiple loose joint bodies; possible osteochondromatosis; chronic inflammatory reaction of the capsule."

The slides, together with the history, were sent to Dr. M. S. Henderson, who was kind enough to review the case. He also entertained the possibility of a diagnosis of osteochondromatosis, but as both our pathologist and the pathologist at the Mayo Clinic, Dr. Krenohen, found neither periosteum nor bone in the loose bodies, the diagnosis of osteochondromatosis was uncertain.

As the left knee was markedly swollen and the joint contour obliterated, we had the impression that there were loose bodies present. Accordingly, we decided to explore the joint as soon as the patient was able to undergo a

On June 3, 1936, the knee joint was opened by a Krida incision. The synovial membrane was found markedly thickened with many large villi and polypi attached by small pedicles, but no loose bodies were found. A regular synovectomy was done and the specimen sent for examination. The wound healed by first intention. The patient had more use of the knee, and under continued treatment, the motion of the knee increased.

The specimen, again examined by Dr. Ferrara, was reported upon as follows:

"*Gross:* Specimen consists of the left suprapatellar bursa and a number of irregular pieces of synovial membrane removed from the left knee joint. On cut section the bursa presents a homogeneous appearance. There does not appear to be any other gross pathologic change. The synovial pieces of tissue vary in size from 1 to 5 mm. in length. From the edges of several of these pieces, a number of polypoid structures are seen to arise. These polypoid masses are pale brown in color, soft and edematous in appearance. Some of them present a short sessile attachment. Others have an elongated stalk. These polypoid masses vary in size from a split pea to a small cherry. The synovial membrane proper is definitely thickened and somewhat edematous."

COMMENT

As the synovial membrane showed distinct evidence of inflammatory changes, we feel that the changes in the shoulder joint were probably also originally inflammatory. The synovial membrane of the knee showed bodies attached with small pedicles. The same condition was probably present in the shoulder joint at the beginning so that the polypoid masses were the forerunners of the loose bodies. We feel justified, therefore, in considering the etiology of the case to be inflammatory.

CONCLUSIONS

1. A case of multiple fibrous loose bodies of the shoulder is reported. Almost 800 loose bodies found in the joint.

2. The synovial membrane of the knee showed many similar bodies, but with pedicle attached to the membrane.

3. The synovial membranes of both joints showed characteristics of chronic inflammation.

4. These loose bodies may therefore be inflammatory or infections in nature.

We wish to thank Dr. Ferraro for his examinations and careful study and Dr. M. S. Henderson for his review of the case.

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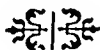
If treated early, the average compound fracture caused by indirect trauma is no more serious than a simple fracture.

NEW INSTRUMENTS

THE POSTERIOR HEEL (CALCANEAL) EXTENSION AND THE ANTERIOR TOE (EQUINUS) EXTENSION*

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ONE of the causes of static weak feet in children is the presence of a congenital calcaneovalgus de-

has also been used in the treatment of congenital and acquired, simple and compound, calcaneal deformities. It has been
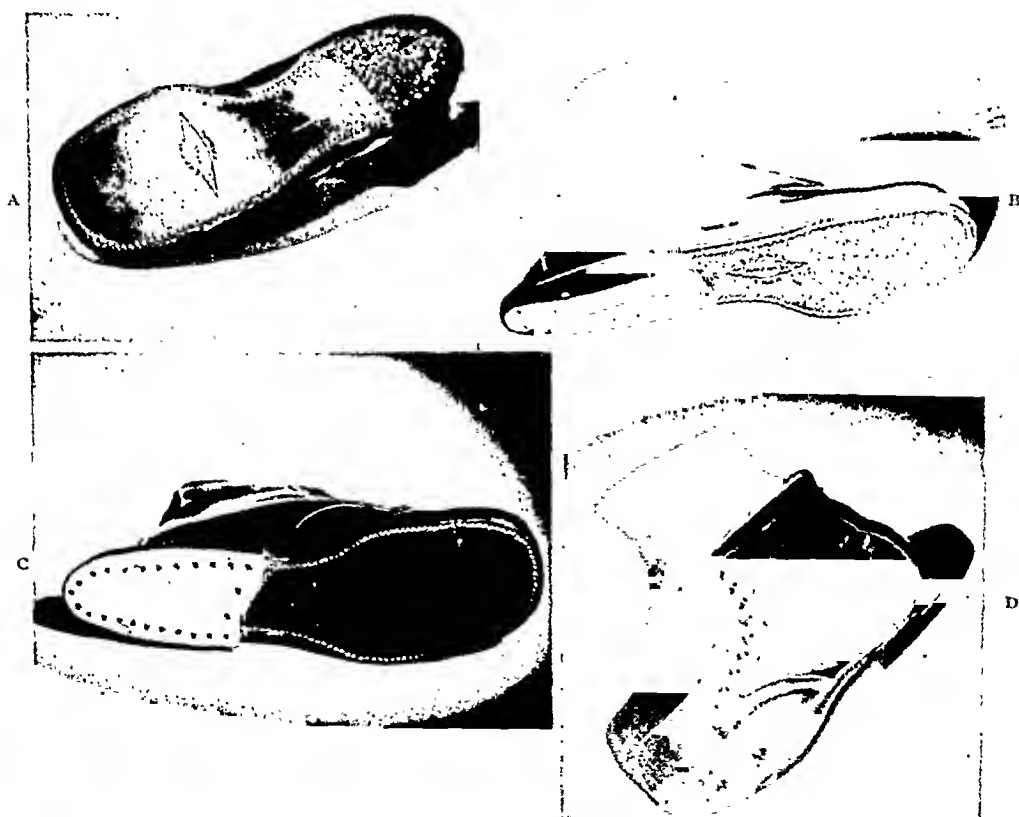
Fig. 1. A, shoe with heel removed to expose the underlying upper. B, new heel extension and steel brace. C and D, shoe with posterior heel (calcaneal) extension.

formity. Occasionally, despite the wearing of Whitman weak foot braces (plates) and of balanced corrective shoes, the gait may remain awkward and the attitude in walking ungainly. The calcaneal heel is suggested as an aid in the further treatment of these patients. This device

used in the treatment of mild paralytic calcaneal deformities to guide the growth of the foot and to aid in the restoration of the weakened calf muscles. The heel is extended posteriorly (Fig. 1) and by its fulcrum action tends to correct the usual heel gait of the patient with a calcaneal tendency.

In making the posterior calcaneal extension, the heel of the shoe is removed to expose the underlying upper. A piece

in relieving the discomfort of patients with a hallux rigidus.

In making the anterior toe (equinus)
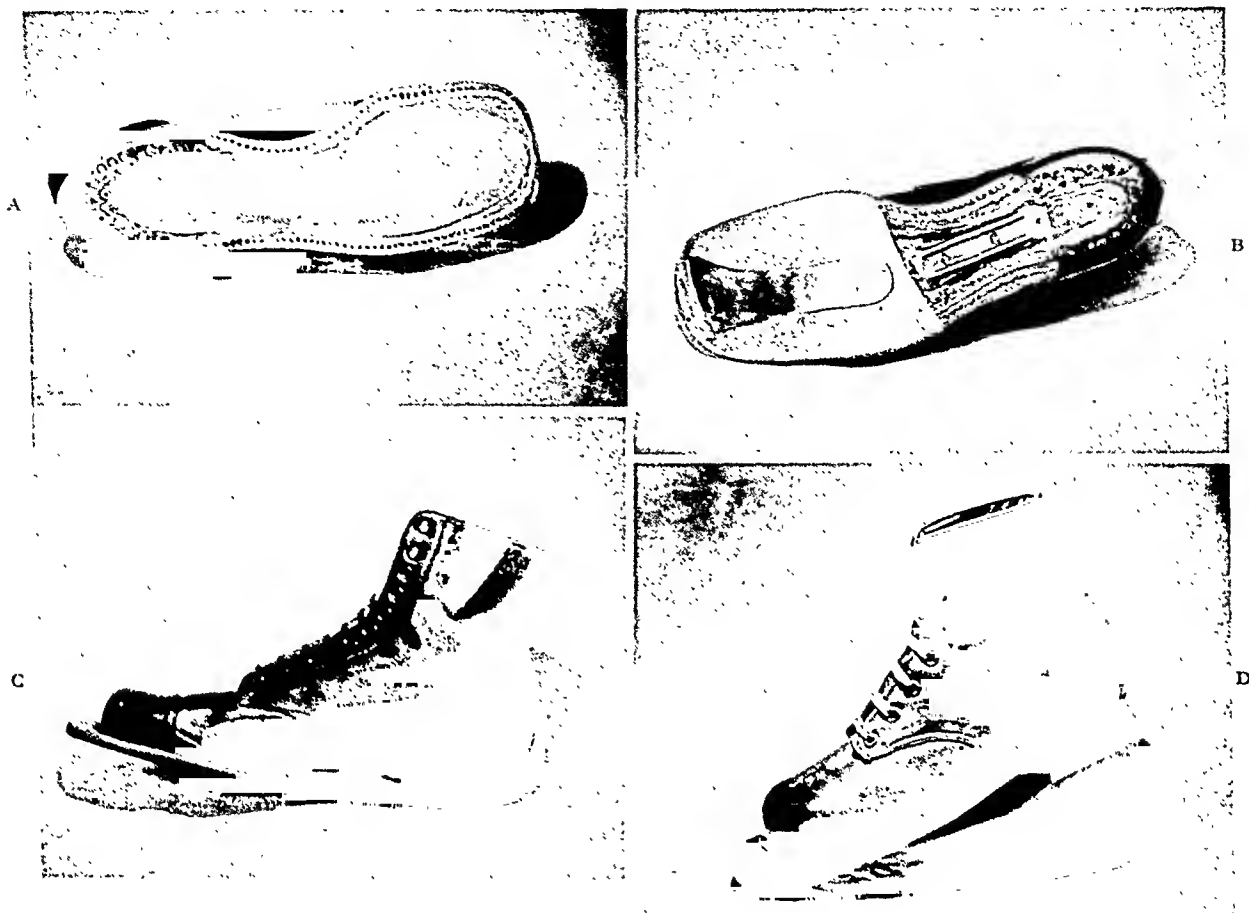
FIG. 2. A, shoe with sole and heel removed to expose the underlying upper. B and C, shoe with new sole extension and steel brace. Note brace extending from the posterior to the anterior surface of the sole, about one inch back from the toe of the shoe. D, shoe with anterior heel (equinus) extension.

of leather is then attached, beginning at the breast of the heel where the sole was cut and extended beyond the shoe for a distance of one inch. (Fig. 1A and B.) A flat piece of steel, to act as a brace, is attached to the new heel to prevent bending when the shoe is worn. A top lift or heel is then applied. (Fig. 1C and D.) The height of the heel may be increased, if desired, to aid further in correcting the calcaneal attitude.

The anterior toe (equinus) extension is used in treating patients with equinus deformities without tendo Achillis contracture. It may be of value, therefore, in cases of mild spasticity of the calf muscle group and for the occasional child who walks on its toes without apparent cause. A short toe extension may also be of value

extension, the sole and heel of the shoe are removed to expose the underlying upper (Fig. 2A) and a piece of leather is then attached to the sole, extending from the seat to 1 inch beyond the toe of the shoe. A piece of steel is incorporated, projecting to the end of the leather piece anteriorly. (Fig. 2B and C.) The heel and a new longer sole are applied. (Fig. 2D.)

SUMMARY

Two shoe corrections are described. Their purpose is to improve the attitude in walking of patients with calcaneus and equinus positions of the foot and ankle as previously described. They tend to make the gait more graceful. There is no awkwardness due to the extensions and the patients do not trip or fall.

[From Fernelius' Universa Medicina, Geneva, 1679.]

BOOKSHELF BROWSING

THE OPERATIVE STORY OF HERNIA

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THE year 1937 marked the fiftieth anniversary of Bassini's first contribution before the Italian Surgical Society, and the treatment of hernia as we know it today can properly be said to have begun with Bassini and Halsted. All attempts at cure before their time were ineffectual and, in the light of present knowledge, extremely crude.

Two examples of the many pre-Bassini-Halsted methods may be mentioned here: The first is that of McEwen who performed an extraperitoneal operation which consisted of making a pad of the unopened sac and fastening it up under the transversalis as far above the internal ring as possible. This was probably the best of the early operations but resulted in many recurrences. We still honor McEwen, however, by implanting the sutured peritoneum after excision of the sac as far superiorly as possible and call it McEwen's maneuver. The second pre-Bassini-Halsted operation, which is of interest, is that of McBurney, particularly because of the prominence of its author. McBurney opened the canal, sutured the sac as high as possible and then packed the canal with iodoform gauze, permitting it to heal by granulation. An extremely high incidence of recurrence

resulted and the state of these patients was pitiable as cure by reoperation was impossible and the wearing of a truss uncomfortable. The results of this operation well illustrate the inability of scar tissue to act as a real supporting structure.

The most complete study of hernia prior to Bassini-Halsted was by Sir Astley Cooper, who wrote a book upon it in 1804. Little has been added to our anatomic knowledge of hernia since Cooper's book appeared and it is somewhat surprising that in spite of this eighty years elapsed before surgeons learned to cure hernia.

The present paper is an attempt to outline the various original procedures and contributions of lasting merit used in the treatment of inguinal and umbilical hernias. Many ingenious and useful modifications of these basic operations have been devised and are probably also worthy of study, but space does not permit their inclusion here.

Edward Bassini, the first name of importance, was born in Pavia, Italy, in 1844 and received the degree of Doctor of Medicine from the University of Pavia when only 22 years old. He became assistant to the Professor of Surgery at Pavia and at once showed an intense interest in anatomy and

surgical pathology. He followed closely the many new developments in surgery at that time and visited the clinics of Billroth in

FIG. 1. Internal oblique and transversalis being sutured to Poupart's ligament. (After Bassini.)

Vienna and Lister in London. He was one of the first Italian surgeons to practice aseptic surgery. In 1882 he was appointed to the chair of surgical pathology of the University of Padua. "He became Professor of Clinical Surgery in 1888 and he held this position until his retirement at the age of 75 in 1919. During this long and fruitful period, his epoch-making work on hernia appeared, as well as numerous other contributions to surgical literature. He was simple, almost austere in his tastes, of rigid moral fiber, a meticulous and cautious operator, and a kindly and interesting teacher. It is not surprising that he enjoyed the affection, as well as the admiration of his associates and pupils. He died in Verona, at the age of 80, on July 19, 1924."[1]

Bassini studied the repair of the inguinal canal upon the cadaver before trying it upon a patient. In 1887 he reported the results of forty-two operations before the Italian Surgical Society, in 1888, reported 100 cases in one of the Italian journals, and in 1889 published a monograph "New Method of Operating for the Cure of Inguinal Hernia" which was printed by R. Stabilmento Prosperini in Padua. This last surveys minutely the results of 262 cases. The book consists of 106 octavo pages and contains four beautifully colored

plates showing the technique used and the anatomic relations at the completion of the operation. In 1890 the results of 251 opera-

FIG. 2. Halsted's original operation. Sac has been excised and peritoneum closed. Cord has been reduced in size with remaining portion held aside. Interrupted sutures have been inserted and are ready for tying. (After Halsted.)

tions were reported in a German journal; outside of Italy little had been known of his work until this article appeared.

"Of the 251 cases, he followed all but four for periods ranging from one month to four and one-half years, itself a commendable achievement in clinical research. There were only seven recurrences in the total series of 251 operations (2.7 per cent), a record of which any surgeon of today could well be proud."[1] The technique of his operation is so well known that no description of it other than that shown in the illustrations will be attempted. The operation described by Bassini is being done today in hundreds of clinics throughout the world just as he performed it. It is doubtful if any other surgical procedure has received without alteration such universal acceptance.

Bassini also originated an operation for femoral hernia which is still extensively practiced. He excised the sac as high superiorly as possible and closed the canal with interrupted sutures uniting Poupart's ligament and the pectineal fascia.

William Stewart Halsted, the first Professor of Surgery at Johns Hopkins University, was born in 1852 and died in 1922. He was the son of a rich New York mer-

chant, a graduate in Arts from Yale College, and a graduate in Medicine in 1877 from the College of Physicians and Sur-

FIG. 3. Revised operation. Method of utilizing cremaster muscle. (After Halsted.)

FIG. 4. Method of using rectus fascia strengthening repair of canal. (After Halsted.)

geons. After two years of study in Austrian and German clinics and eight years of teaching anatomy and practicing surgery in New York City, he went to Baltimore in 1889 as Chief Surgeon to the Johns Hopkins Hospital.

Time will not permit a complete recital of Halsted's contributions to the art and science of surgery. He was the first American surgeon to practice completely aseptic surgery. He introduced regional anesthesia and rubber gloves. He devised the first effective operation for cancer of the breast and independently of Bassini developed an operation for the cure of hernia.

Halsted's first operation was performed June 13, 1889 upon an 8 year old colored boy for a large congenital inguinal hernia on the right side. The sac when opened contained cecum and vermiform appendix. Upon November 4, 1889 before the Johns Hopkins Hospital Medical Society, Halsted presented an account of his first five cases. This was later reported in Volume I of the Johns Hopkins Hospital Bulletin. Halsted did not learn of Bassini's work until 1890 when it first appeared in German.

Halsted's operation differed in details but not in principle from Bassini's. His technique was as follows:

"1. The incision begins at the external abdominal ring, and ends 1 inch or less (less than 1 inch in children) to the inner side of the anterior superior spine of the illium on an imaginary line connecting the anterior superior spines of the illia. *Throughout the entire length of the incision everything superficial to the peritoneum is cut through.*

"2. The vas deferens, with its vessels, is carefully isolated up to the outer termination of the incision and held aside.

"3. The sac is opened and dissected from the tissues which envelop it.

"4. The abdominal cavity is closed by quilted sutures passed through the peritoneum at a level higher by $1\frac{1}{2}$ to 2 inches than that of the so-called neck of the sac.

"5. The vas deferens and its vessels are transplanted to the upper outer angle of the wound.

"6. Interrupted, strong silk sutures, passed so as to include everything between the skin and the peritoneum, are used to close the deeper portion of the wound, which is sewed from the crest of the pubes to the upper outer angle of the incision. The cord now lies superficial to these sutures, and emerges through the abdominal muscles about one inch to the inner side of the anterior superior spine of the illium.

"7. The skin is united over the cord by interrupted stitches of very fine silk."[15]

The first cases were drained with gauze, but this was soon abandoned and the wounds closed without drainage. At first

Fig. 5. Overlapping method of repairing umbilical hernia. (After Mayo.)

Halsted laid great stress upon transplantation of the cord and reduction of the size of the cord by excision of some of its veins. Transplantation was later considered unnecessary and venous excision was abandoned because of resultant testicular atrophy in some cases.

In his final modification Halsted no longer used the through-and-through sutures; instead he utilized the cremaster muscle to reinforce the internal oblique and transversalis. The internal oblique was then sutured to Poupart's ligament and the external oblique closed by imbrication. He considered the most important part of his operation the wide exposure with high ligation of the sac. I believe that most of the poor results today are primarily due to failure to follow the principles taught by Halsted in his first paper. Unquestionably the most important of all is high suture of the sac.

After 1890 Bassini made few if any additional contributions to the study of hernia while Halsted continued to study the subject and made nine separate printed

contributions, the last one of which was prepared in August 1922 and appeared after his death. In his last article he made
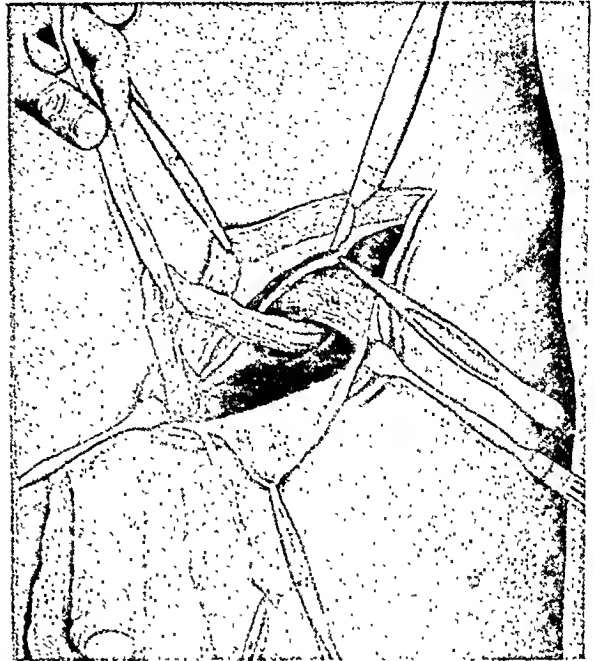
Fig. 6. Method of obtaining autoplastic sutures. (After McArthur.)

the following statement: "There is not in any language a study of the ultimate results or of the relative importance of the various details of the operation comparable to ours." Both Bloodgood and Taylor made valuable studies of the Halsted material and results and Cushing, of the Halsted clinic, was probably the first to perform the operation with local anesthesia.

The second of Halsted's longer papers, "The Cure of the More Difficult as Well as the Simpler Inguinal Ruptures," which appeared in the Johns Hopkins Hospital Bulletin for 1903, gave illustrations of his modification of his original operation. Here too is an account of his transplantation of the rectus sheath for the larger direct hernias. This maneuver was also done independently by a French surgeon named Berger.

In practically all of his operations Halsted used sutures of fine silk. His studies of the reaction of wounds to different suture materials were extensive and thorough and he used the fine silk sutures because of a higher percentage of primary healing and better final results. Wangen-

steen[12] has recently made the following statement relative to silk sutures: "I am inclined to believe that the silk sutures

FIG. 7. Fascial sutures in repair of hernia. (After Gallie.)

which Kocher and Halsted employed and recommended are an important item in the surgical repair of hernia. I believe that surgeons will employ them with increasing frequency." In his last paper upon hernia, Halsted stated that he had not had a recurrence in over twenty years.

After Bassini, the cure of hernia is entirely an American contribution. The second American to distinguish himself in this field was W. J. Mayo who was born at New Ulm, Minnesota, and who has practiced surgery in Rochester, Minnesota since 1883. Prior to Mayo's studies, efforts to cure umbilical hernia were directed toward covering the defect with muscle. Failure followed in almost all cases and until his time umbilical hernia was considered a hopeless condition.

Mayo's first operation was performed in 1895 and consisted in overlapping, from side to side, muscle and the aponeurotic structures which compose the neck of the hernia. Later he found that overlapping of fibrous structures only from above downward was preferable. In his first report he covered five cases. His description of how he first used the above downward overlapping is interesting.[6] "This method we had then employed in five cases: in three the overlapping was from side to side, and in two from above downward. Extensive lateral incisions to find sufficient muscle to make the routine operation described by surgical writers compelled us, as a matter

of necessity, to overlap from above downward in these two cases and, to our satisfaction, we found the parts came together

FIG. 8. Transplantation of fascia with pedicle. (After Wangensteen.)

with less tension than when drawn laterally, and time proved that the strength of union was as lasting."

In addition to being the most widely accepted method of treatment of umbilical hernia, the principle of Mayo's operation is utilized in treating post-incisional and other forms of ventral hernia.

The next original contribution of lasting merit was by Lewis L. McArthur of Chicago. McArthur was the first to use fascial sutures, the strips of fascia being obtained from the split aponeurosis of the external oblique. McArthur made a preliminary report in 1901 before the Chicago Surgical Society, and a subsequent report covering eighty-five patients in October 1904 in the Journal of the American Medical Association. McArthur reported no known recurrences in the eighty-five patients, eight of them having bilateral repairs. The technique of McArthur's operation is clearly shown in his illustrations. He noted that his method was equally adaptable to the Bassini, Halsted and other procedures.

In 1909, Kirschner demonstrated the feasibility of using free transplants of fascia lata for various operations. These transplants were used as substitutes for dura and tendons, for reinforcements of tendons, as substitutes for articular ligaments and other operations.

In 1921, W. E. Gallie and A. B. Le-Mesurier of Toronto, dissatisfied with their own and other surgeon's results in large, direct and recurrent hernias, went a step further than McArthur and Kirschner and used free transplants of strips of fascia lata. Their clinical work was predicated upon a series of carefully executed experiments. Studies were made of the effects of catgut, silk, and fascial sutures when inserted into the supporting structures of animals. They demonstrated experimentally that supporting structures sutured with autogenous free strips of fascia were much more strongly united than when sutured with catgut, linen or silk.

Gallie's results with this method have been excellent indeed, particularly so since practically all of his operations have been for extremely large primary or recurrent hernias. Their method is used for inguinal, umbilical and ventral hernias. In 1930 Gallie[11] reported a series of 200 cases with only six failures, although "among them were ventral and inguinal hernias so enormous as to be almost unbelievable." Gallie's method has received wide approval and acceptance by other surgeons.

James C. Masson[13] made the following statement of his experience: "During 1936 we used living sutures in the repair of hernia in 145 cases. Some of them were huge postoperative hernias and the others were either direct or recurrent inguinal hernias. Altogether we have used fascia lata transplants in about 745 cases of postoperative or inguinal hernias."

The strips which Gallie uses are cut from the fascia lata through incisions in the lateral surface of the thigh. They are one-fourth inch wide, the length varying with the needs of the individual case, some of them being as long as 10 or 12 inches. Gallie sutures the defect in the thigh. Some surgeons have devised instruments for cutting the fascial strips through small puncture wounds and leaving the defect unsutured. In his papers upon hernia, Gallie has insisted, and properly so, that supporting structure must be united to

supporting structure without intervening areolar or other tissue.

In 1931, after removing a large desmoid tumor from the left lower abdominal wall in a young woman, Wangensteen found the resulting defect so great that he was unable to close it by approximating the residual tissues. The opening seemed to be too large to close with woven free strips of fascia lata so "the plan of employing the iliotibial tract as a pedicled graft on the tensor fascia lata muscle suggested itself as a feasible procedure."[14] The results were so satisfactory that he subsequently used the method with success in recurrent and large hernias of all types.

After exposing the defect in the abdominal wall, Wangensteen makes a long elliptical incision in the thigh and raises a large flap of fascia lata with the pedicle composed of muscle tensor fasciae latae. The flap is then sutured into or across the defect. In repairing inguinal hernias, Wangensteen carries the flap anterior to Poupart's ligament, but for incisional hernias it is brought posterior to the ligament. The defect remaining in the thigh has not resulted in any disability. Wangensteen's operation has not been used sufficiently by other surgeons to determine properly its indications and value, but as it is based upon sound surgical principles it has real merit. There is no doubt that it will be of definite usefulness in the treatment of very large hernias.

CONCLUSION

As previously stated, many modifications of technique in treating hernia have been omitted in this paper. It is believed, however, that the principles of treating hernias have been presented. We can agree with Halsted, whose last written words upon the subject were, "The cure of hernia may be listed with the triumphs of surgery."[5]

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Compound fractures from direct trauma are far more serious and radical measures are necessary if sepsis is to be avoided and the limb saved.

The fillers in this issue are from "Experience in the Management of Fractures and Dislocations" by the Staff of the Fracture Service, Massachusetts General Hospital (Lippincott).

The Rôle of the Electrical Potential of Cells and Tissue Fluids in Normal and Pathologic Metabolism

A Guide to Rational Preoperative and Postoperative Therapy

BY

RUDOLF KELLER, Ph.D.

AND

EDWARD SINGER, M.D.

THE ROLE OF THE ELECTRICAL POTENTIAL OF CELLS AND TISSUE FLUIDS IN NORMAL AND PATHOLOGIC METABOLISM[*]

A GUIDE TO RATIONAL PREOPERATIVE AND POSTOPERATIVE THERAPY

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ELECTRICAL phenomena were examined in electrically charged submicroscopic (colloidal) and amicroscopic (ionized) particles. This paper is devoted to a study of the electrical phenomena that occur in microscopic dimensions, that is in cells, and to the behavior of molecules which migrate in the cells. As the surface potentials of non-electrolytes play the most important rôle here, the discussion will be largely about the electrokinetic potential, the ζ potential[†] of Freundlich.[11] Although the magnitude of this potential is only about 1/100,000 of the potential with which one deals in ionic chemistry, it is a basic factor in all biologic occurrences and is fundamental in cellular metabolism.

The importance of the electrical potential in cell metabolism has been suspected for some time, but careful and exact investigation of this problem has been possible only in the last decades. We have only recently achieved sufficient perfection in micromethods to enable us to measure electrical currents of a few microvolts and microamperes in single living cells. For the development of the methods available for this investigation American research workers are largely responsible. Chambers[3] devised the first micromanipulator. The electrical potentials of single nerve cells and muscle cells were measured by Lillie[26] and Gasser,[14] those of algae cells by Osterhout,[34] Blinks[2] and Irwin[18] various parts of plants by Lund,[28] Marsh,[29] and Rosene,[40] and the unfertilized and fertilized ova by Gelfan.[15] Besides actual measurements vital staining was also used to discover the electrical potential of cells, and Singer[44–50] described the electrical potential of kidney and suprarenal cells based on experiments with fluorescent vital staining.

† The potential difference represented between the potential of a fluid adherent to a solid wall against the movable fluid in the inside. This potential difference is dependent upon the nature and concentration of the substances dissolved in the fluid.

It is necessary to include the results of the investigations of these authors and other information from the literature in order to arrive at a more general conclusion than would be possible to on the basis of our findings alone. The experimental data already published are of real significance and when correctly coordinated supply further evidence for our interpretation. As a matter of fact a critical reëxamination of findings already recorded from the aspect of electrical structure forms an essential part of this work. The electrical structure of the various organs will be described and compared with their optical and mechanical structure. Thus a normal and pathologic electrohistology will be given.

METHODS OF INVESTIGATION

Conclusions to the electrical structure of organs can be made by vital staining. Vital staining with fluorescent dyes is especially useful and laws governing color appearance are systematized in Table 1.

The results of the vital stainings are controlled by reëxamination with the multielectrodes of Nistler.[31] These two methods of examination supplement each other, as both have inherent errors that one can not easily eliminate. Negatively charged particles penetrate easily into normal cells, while positively charged particles can be introduced only with difficulty for the most part. The results of vital stainings are therefore displaced in the positive direction. This error is even greater with the ordinary daylight visible dyes. In measurements with micro-electrodes the error is in the opposite direction. The positive granuli and membranes are in many cases smaller than the finest micro-electrodes and therefore the surrounding negative plasma substance is measured, at least in part, with them. Accordingly micro-electrical measurements are displaced towards the negative direction.

INTERRELATIONSHIP BETWEEN ELECTRICAL POTENTIAL AND MINERAL (RESIDUAL ASH) AND ORGANIC CONTENT OF ORGANS

According to their electrical charge, organs contain various minerals and organic substances. Therefore, the mineral content is characteristic of the physiologic and pathologic states of organs and of the entire organism. A definite alignment is manifested between the positive sodium group and the negative potassium group in the positively and negatively charged organs. Various members of these

antagonistic groups were described by Jacques Loeb,[27] who was the first to notice this antagonism and who called attention to the counter-effect of NaCl to poisoning with KCl.

TABLE I

VITAL STAINING WITH FLUORESCENT SUBSTANCES
THE DECISIVE FACTORS FOR THE STAINING ARE THE PHYSICO-CHEMICAL PROPERTIES OF THE FLUORESCENT DYES AND THOSE OF THE LIVING TISSUES.

I THE PHYSICO-CHEMICAL PROPERTIES OF THE COLOR PRODUCING SUBSTANCES:

    A. THE ELECTRIC CHARGE POSITIVE DYES ARE ATTRACTED BY NEGATIVE TISSUES AND VICE VERSA THE CHARGE IS UNSTABLE ON MOST OF THE COLOR PRODUCING SUBSTANCES AND VARIES IN THE SAME ELECTRIC FIELD ACCORDING TO

        1 CONCENTRATION in dilated solutions particles are absorbed by the serum colloids of opposite charge and take the charge of the colloid

        2 pH not highly dissociated acid and alkaline fluorescent dyes change their charge according to the electric field in which they travel

        3 SIZE OF THE PARTICLES IN THE DISPERSED PHASE
          A coarse dispersed 0.1mm-500μ
          B colloid dispersed 500mμ-1mμ
          C highly dispersed 1mμ

    B SIZE OF THE PARTICLES IN THE DISPERSED PHASE OF THE COLOR PRODUCING SUBSTANCE WILL INFLUENCE THE DIFFUSIBILITY

    C. CHEMICAL AFFINITY

    D OXIDABILITY AND REDUCIBILITY

    E SURFACE DYNAMIC ACTION OF THE PARTICLES

II THE PHYSICO-CHEMICAL PROPERTIES OF THE LIVING TISSUE

    A THE ELECTRIC CHARGE POSITIVE TISSUE ATTRACTS NEGATIVE DYES AND VICE VERSA

    B MECHANICAL STRUCTURE AND TRANSMISSION DENSITY THIS MAKES IT POSSIBLE OR IMPOSSIBLE FOR THE SUBSTANCE TO TRAVEL TO DIFFERENT PLACES OF ATTRACTION DIFFERENCE IN STAINING ACCORDING TO THE MANNER OF APPLICATION

    C. pH ALKALINE POSITIVE WILL NEGATIVIZE THE ELECTRICALLY UNSTABLE FLUORESCENT SUBSTANCES ACID NEGATIVE WILL POSITIVIZE THE ELECTRICALLY UNSTABLE FLUORESCENT SUBSTANCES AT THE ISOELECTRIC POINT THERE IS NO STAINING

VITAL STAINING IS NOT GOVERNED BY THE FOLLOWING CHARACTERISTICS OF THE COLOR PRODUCING SUBSTANCES

    I. ACIDITY OR ALKALINITY IN DISTILLED WATER THE RELATIVE ACIDITY OR ALKALINITY CHANGES ACCORDING TO THE ISOELECTRICAL NIVEAU OF THE GEL MEMBRANES IN THE LIVING CELLS.

    II. CHEMICAL CONSTITUTION CHEMICALLY CLOSELY RELATED SUBSTANCES BEHAVE DIFFERENTLY AND SIMILARLY ACTING SUBSTANCES BELONG TO A VARIETY OF CHEMICAL GROUPS

    III. SOLUBILITY IN LIPOIDS NOT DISSOCIATED (IONIZED) MOLECULES PENETRATE LIVING CELLS EASIEST LIPOIDS AND OTHER SOLVENTS, KAOLIN, CHARCOAL, ETC., WITH LOW DIELECTRIC CONSTANT SEEM TO HAVE A SPECIAL AFFINITY TO THESE SUBSTANCES WHICH WATER WITH HIGH DIELECTRIC CONSTANT DOES NOT HAVE LACK OF DISSOCIATION NOT LIPOID SOLUBILITY IS IMPORTANT

    1 blood serum, lymph, tissue and cell fluids secretions
    2 phase designates the parts of a substance that are separated by physical means dispersed, internal, phase is the aggregate of finely divided suspended particles of a colloidal solution
    3 reductivity of a non-conductor

According to Loeb's interpretation an antagonism exists not between two ions of opposite charge but between ions of the same charge. The riddle created by this important discovery was solved by the recognition, that the effect is not caused by "ion antagonism." Ionized potassium migrates in the electric field in the same direc-

tion as ionized sodium. The antagonism is, however, between the positive ions of sodium and the (in organic compounds) non-ionized potassium complexes.

Tisdall,[52] Gamble,[13] and Fenn[7] also found that minerals migrate in two antagonistic groups. Nearly all members of these two antagonistic groups were discovered by Wertheimer,[56] who proved, by using a frog's skin as membrane, that K, Mg, NH₄, glucose, and basic dyes (negative group) migrate from inside to outside; while water, Na, Cl, amino acids, salicylates, rhodanide, and acid dyes (positive group) migrate from the outside to the inside. Keller[21] and his co-workers tested these substances in the high tension apparatus of Fürth[12] in presence of an overplus of biologic colloids, which adsorb one or the other. They found that K, the potassium group, was negative, and Na, the sodium group, was positive.

Therefore a study of these groups will give us clues to electrical phenomena in the organism where at present direct measurements are impossible. (Table II.) The alignment of these groups in the

TABLE II
ANODIC SUBSTANCES IN BLOOD PLASMA
(Negatively charged in blood plasma)

Basic Dyes:
 Methylene blue, neutral red, methyl violet, chrysoidin, acriflavine, safranine, malachite green. (In distilled water these dyes are positively charged.)

Acid Dyes:
 Congo red (coarsely dispersed), trypan blue, isamine blue. (In section these dyes act positively charged.)

Other Substances:
 Glucose, urea, cholesterin, uric acid, creatinine, ammonium salts, potassium salts, sulfates, phosphates, insulin, gluthatione, non-dissociated calcium and non-dissociated magnesium, iron, iodine, silver salts, manganese, cobalt, arsenic, India ink, hormones, vitamins (with the exception of vitamin C).

CATHODIC SUBSTANCES IN BLOOD PLASMA
(Positively charged in blood plasma)

Basic Dyes:
 Hematoxylin

Acid Dyes:
 Fluorescein, uranin, eosin. (In distilled water these dyes are negatively charged, but in section positively.)

Other Substances:
 Water, chloride, bromide, salicylic acid, rhodanide, esculin, vitamin C, sodium.

normal organism can be seen from Fig. 1, which shows that in comparison with the average content of the organism as a whole, the negatively charged organs have an excess in water and in the Na group, and a deficit in the K group, while the positively charged organs show the reverse condition.

Organs	Charge in MV	H$_2$O	Na	Cl	Mg	K	Glucose
CORNEA	− 15						?
VITREOUS BODY	− 10						
LUNG	−18						
SERUM	− 18						
LENS	+ 5						?
MUSCLE	?						
LIVER	+ 100						
ERYTHROCYTE	+ 10						
CORTEX OF KIDNEY	+ 12						
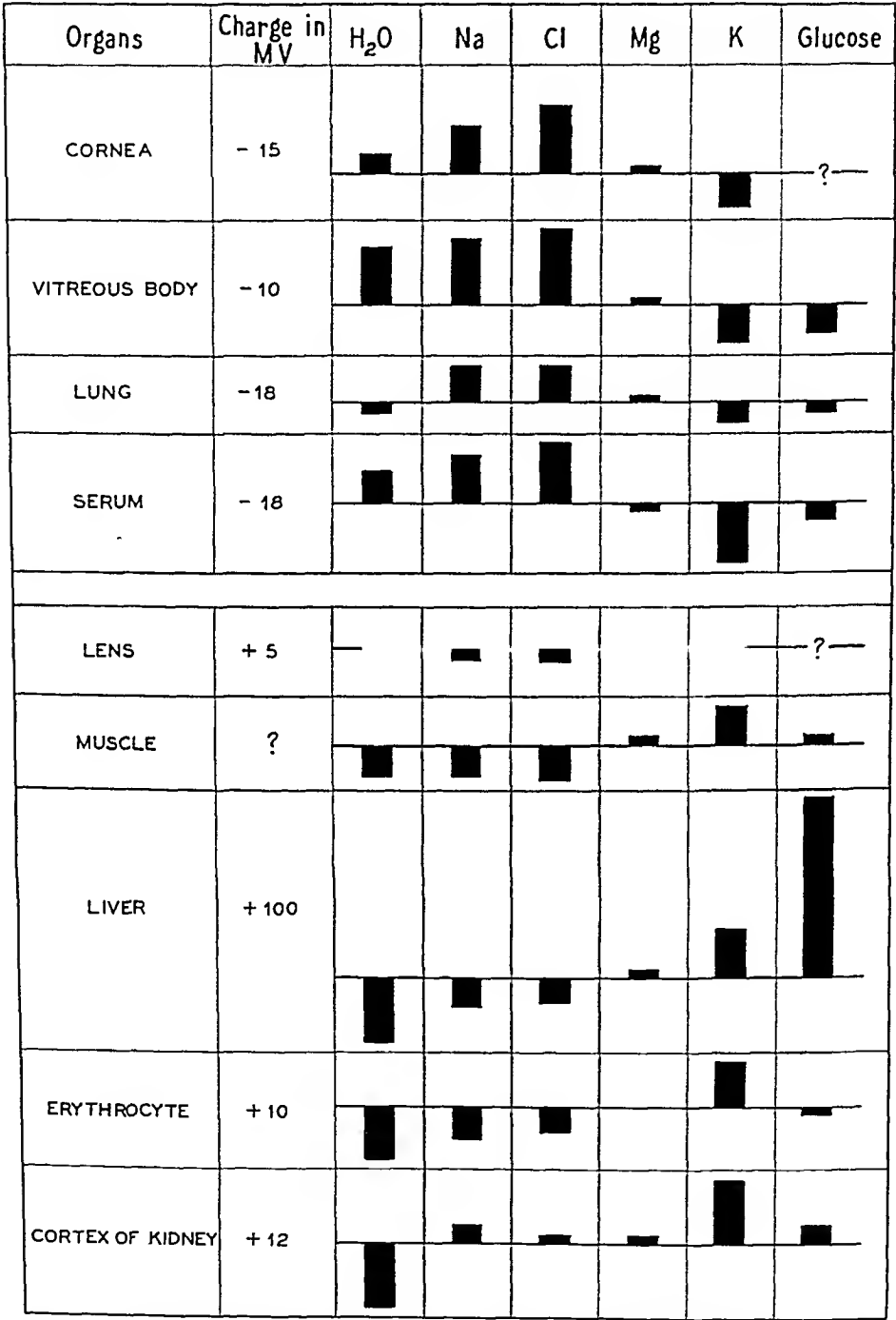
FIG. 1. The negatively charged organs have an excess in water and in the sodium group and a deficit in the potassium group, while the positively charged organs show the reverse condition in comparison to the content of the whole organism in these groups.

THE ELECTRICAL POTENTIAL OF VARIOUS ORGANS

THE LIVER

The electrical potential of the liver cells was first examined by Okuyama[33] who measured the oxidation reduction (redox) potential with gold electrodes and found that the liver parenchyma cells had 100 to 150 millivolt positive tension. Gicklhorn[17] Kaunitz and Schober,[20] Dejdar,[5] and Nistler[31] found by measuring with egg albumin micro-electrodes that the potential of the parenchyma cells of the liver of frogs and salamanders had a positive tension of only 25 to 30 millivolts. Since measurements with micro-electrodes give only rough, quantitative results and the numerical outcome depends greatly on the methods applied, one can understand the numerical difference between Okuyama's and other experiments. The significant point in these experiments is, however, not the numerical result, but the sign of the potentials. All investigators who have measured the potential of the liver parenchyma, have found it positive. Vital stainings with dyes that are visible in ordinary light and with dyes that are fluorescent have confirmed these findings. Thus as far as a qualitative analysis is concerned, the liver has parenchyma cells with strongly positive protoplasm. Quantitative estimation of the results varies, but lower figures were found by the majority of investigators. We shall therefore accept in our calculation the lowest figures as correct.

As these potentials exist in distances of 0.002 mm. between the positive parenchyma cells and the negative bile capillaries (potential 20 millivolt negative), the potential difference per centimeter is 425 volts. The liver is therefore a real high tension apparatus.

The highly positive charge is characteristic of the normal liver parenchyma cells. These cells, however, are storage places for biologically electro-negative substances, such as glucose, glycogen, phosphates, urea, potassium compounds, a majority of the vitamins, and basic dyes. These substances are attracted, while the biologically electro-positive substances, such as water, sodium chloride, amino acids, and acid dyes are energetically repelled.

In various pathologic conditions the electrical charge of the liver parenchyma becomes lowered. The parenchyma cells lose the ability to attract negatively charged substances and to repel positively charged ones, with the result that the storage of potassium, glucose, and phosphates is diminished and the content of sodium and water increases. When this occurs acid dyes are able to enter

the liver parenchyma, as was demonstrated by Roller and Schober. When uranine is injected into an animal with normal liver, this acid dye appears in the vessels of the liver and in the bile capillaries,
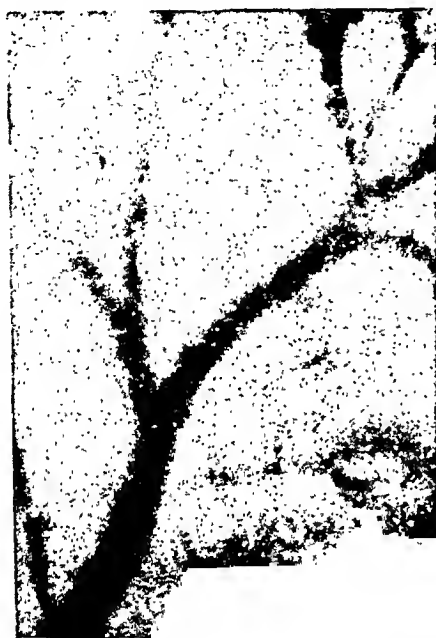
FIG. 2. The superficial veins of the liver in fluorescent light of uranine.

FIG. 3. The same area as in Figure 2 after poisoning with allyl formiate, showing typical accompanying band (Begleitstreifen).

but the parenchyma cells do not show it. By injection of allylformiate Roller and Schober[38] were able to depress the electrical charge of the parenchyma within a few minutes and could make the liver edematous. Uranine then entered the parenchyma cells along the blood capillaries and formed a luminous band (Begleitstreifen) bordering them. (Figs. 2 and 3.)

A fall in the electrical potential of the liver parenchyma can also be observed after various other poisonings, after severe operations, blood loss, and impairment in circulation. It might also be caused by lack of oxygen, fever, chronic diseases, and diphtheria toxin.

Kaunitz[19] observed in his analysis of residual ash of livers of guinea pigs a loss in the biologically negative potassium group during the effect of low oxygen pressure, poisons and diseases; but changes that for themselves could be used for interpretation were not evident from the figures of the biologically positive sodium group. It becomes clear, however, by the calculation of the molecular K/Na ratio,

that there was in every case a relative displacement of K in favor of Na. (Table III.) On the other hand drugs of the pyramidon, digitalis, and strophanthin groups increased the potential of the liver parenchyma above normal.

TABLE III
AVERAGE POTASSIUM AND SODIUM CONTENT OF GUINEA PIG LIVERS

Diagnosis	No. of Animals	K—mg. Per Cent	Na—mg. Per Cent	K/Na Molecular Ratio
Normal..........................	32	273	134	1.19
Diphtheria toxin...................	6	234	135	0.99
Urea poisoning....................	3	121	79	0.89
Cholesterin poisoning..............	2	181	130	0.82
Allyl formiate poisoning............	2	116	234	0.30
Low oxygen pressure...............	19	167	126	0.76

The results of various types of research work done on the liver indicate that the electrical potential of the liver parenchyma reflects the physiologic or pathologic state of the cells.

THE ERYTHROCYTES

Normal erythrocytes contain a large amount of negatively charged substances, such as glucose, glycogen, urea, potassium lactate, phosphates, etc., and accumulate basic dyes. The storing of these substances is caused by the positive charge of the principal parts of the erythrocytes. Some parts of the erythrocytes, however, have a negative charge according to Gicklhorn's[17] observations. He could stain a thin membrane around the erythrocytes of the salamander by the acid dye uranine. A framework within the erythrocytes appeared also. Keller[22] and Singer[51] could not observe any staining in the membrane of red blood corpuscles that were in the blood stream of capillaries. Singer observed after the application of acriflavine only a staining, which appeared in the nuclei of the red blood corpuscles of the frog. A failure to produce staining, or more correctly in this case, a lack of fluorescence, might be due, however, to the filter effect of hemoglobin to the ultra-violet rays.

The erythrocytes of the salamander are relatively large (55μ in diameter) and therefore Gicklhorn was able to measure their outer membrane against their inner parts with an electro-potential meter. The results of these measurements were in accord with the vital staining. They disclosed that the outer membrane was 10 to 11 millivolt negative in comparison to the inner parts.

Seki[42] came to a similar conclusion by measuring the charge of the erythrocytes by an entirely different method, namely by their cataphoresis. He saw the erythrocytes migrating to the anode. The velocity with which the erythrocytes migrated in the electric field, however, varied not according to the size of the erythrocytes (Lamb's[25] law) but independently of it, according to the species of the animals from which blood was obtained. The velocity for the dog was 1.7μ for the cat 1.5μ, for man 0.9μ, and for the rabbit 0μ, per second. He called attention to the fact that cataphoresis reveals only the potential difference between the surface of the cell and the surrounding fluid; the inside potential of the cell has no effect on it. His staining experiments, however, indicated that the inside of the erythrocytes has a positive potential. Independently of Gicklhorn he concludes from his cataphoresis experiments, that the erythrocytes are surrounded by a differentiated outer layer or membrane, which is formed by a negatively charged substance. The gradient of the electrical charge, which the erythrocytes of the various animals possess, depends upon substances that imbibe the membrane. He first thought the substance might be a lipoid, later he came to the conclusion that it might be an individually different hemoglobin. The analysis of the mineral contents of the erythrocytes, however, suggests an entirely different reason for the variation in the electrical charge. The sodium and potassium content of the erythrocytes of these animals is shown in Table IV. Taking the

TABLE IV
SODIUM AND POTASSIUM CONTENT OF ERYTHROCYTES IN MAN AND ANIMALS

	Dog	Cat	Man	Rabbit
Sodium	0.28	0.27	0.1	0.13
Potassium....	0.02	0.02	0.33	0.43

figures of this table into consideration, the gradient of the electrical charge of the erythrocytes is parallel with their potassium and sodium content. As for the glucose, urea, fat, and lecithin content, one would expect a higher amount, but other minerals confirm the group rule. We may conclude, that for erythrocytes the different methods used by the various investigators, vital staining, mineral analysis, fluorescence by ultra-violet light, and measurements by micro-electrodes and cataphoresis gave the same results.

MUSCLE

Experiments for the determination of the electrical charge of the intact muscle meet with such difficulties and the results are often

so contradictory that their validity has to be questioned. One of the reasons is that muscle tissue is extremely sensitive to manipulations. Injuries that are not perceptible to the naked eye cause a typical injury or cathode current. Vital staining is also difficult. Some staining was obtained with negatively charged dyes, but they stained only granules. On the mineral metabolism, however, we possess exact data.

Fenn[7] found that muscle during action loses potassium and increases its sodium content. This phenomenon is characteristic of nearly all organs. His figures on the average electrolyte changes in the rat gastrocnemius muscle during stimulation can be divided into two characteristic groups. (Table v.) The negative group,

TABLE v

ELECTROLYTE CHANGES IN RAT MUSCLE

(Concentration in millimolls per 100 gr. dry weight)

	Average Content	Change in Stimulation	Change in Recovery
Negative K	47.3	− 6.1	+ 3.6
Positive Group { Na	7.6	+ 8.3	− 6.4
Cl	5.4	+ 2.8	− 2.0
H₂O	318	+49	−43

represented by potassium, leaves the muscle, and the positive group, represented by sodium, chlorine, and water, enters into it. Kaunitz in some unpublished analyses obtained somewhat similar results. From inference we may conclude that muscle has a positive charge, which becomes depressed by fatigue or exhaustion and which will be resumed or restored by rest.

NERVOUS TISSUE

On the basis of his studies in fresh frozen sections, Unna[54] described nervous tissue as a place of reduction. A site of reduction is equivalent to a cathode. (Reduction takes place at the cathode.) Kreibich's[24] experiments on living objects with rongalit white revealed that nervous tissue is a site of oxidation, which is identical with the anode or a place of positive charge. Gicklhorn and Keller[23] were able to demonstrate that nerve tissue can be the site of either reduction or oxidation in the same animal, depending upon its functional state. Thus both Unna's and Kreibich's statements are correct.

Organic specific vital staining of sensory nerve fibers was accomplished by means of diluted methylene blue in cocaine in daphnia.[23]

The dye appeared first in the nine rods of the peripheral organ, hypothetical taste organ (Riechstäbchen) of the animal. From the rods the dye migrated into the nine peripheral ganglia, then through
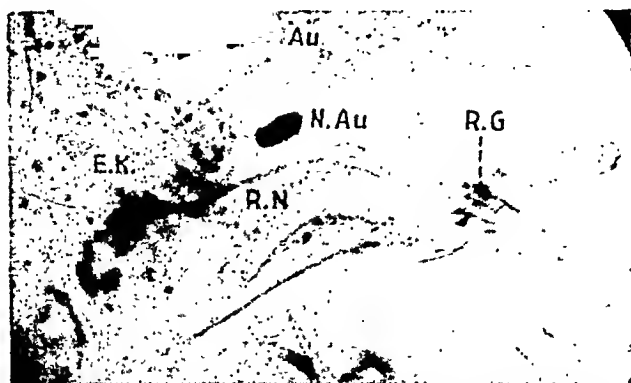
FIG. 4. Elective vital staining of the taste organ of daphnia magna. RN, olfactory nerve, EK, end basket, RG, ganglion, AU, eye, N.AU, naupilus eye.

FIG. 5. Elective vital staining of the taste center of daphnia magna.

the axons into the central ganglia (Schlundganglion). The "Schlundganglion" contains forty-two cells, of which only nine, those belonging to the peripheral rhinosphere rods, became colored by methylene blue. (Figs. 4 and 5.) The stained rhinophore ganglia are in the midst of the other thirty-three ganglia which were not influenced by this staining at all.

This distribution of methylene blue, according to our experience, reveals that a positive charge exists in the central ganglia against the peripheral ganglia and nerve fibers. The peripheral ganglia and nerve fibers are positive without any doubt, however, in relation to their surrounding medium. The potential of this charge was estimated by Gasser[14] on the basis of the electrolyte distribution. (Table vi.) According to the electrolyte distribution the potassium concentra-

TABLE VI

PROBABLE ELECTROLYTE DISTRIBUTION IN THE FROG NERVE

(Concentration in millimolls per cent)

	Inside Axon	Outside Axon
Potassium..	17.6	0.27
Sodium.....	3.7	10.8
Calcium.....	0.96	0.21
Magnesium..	2.4	0.34

tion at the interior is sixty-five times that at the exterior, which would permit a potential of 118 millivolts.

Gerard's[16] analyses supply good evidence for the relative electropositivity of the brain against the peripheral nerves. According to him the brain of mammals contains one and a half or two times as much potassium as the peripheral nerves, and correspondingly less sodium. The brain, however, is full of axons with less potassium and more sodium and also contains numerous blood capillaries with a Na:K ratio of 30:1. Thus an average content of twice as much potassium for the whole brain means in reality a multiple of this figure for the pure ganglion cells.

During stimulation the potassium content of the nerves diminishes in a way similar to that of muscle. Advanced age and disease seem also to have a similar influence according to Petrunkin and Petrunkin,[36] who analyzed the brains of healthy persons killed by accidents. They found more potassium and less sodium in the brains of young and healthy persons than in those of old or sick persons. (Table VII.)

TABLE VII

K, Na AND CL CONTENT OF BRAINS

	K	Na	Cl
18 years (normal)...............................	4.19	0.94	1.31
60 years (normal)...............................	3.60	1.10	2.07
Tuberculosis....................................	3.63	1.36	1.50
Pneumonia......................................	4.01	1.53	1.86
Nephrosclerosis (62 years)......................	3.90	1.34	1.85
Cancer...	3.83	1.41	1.68

It seems on the whole that the parenchyma of all organs suffers losses of the potassium group and makes gains in the sodium group and water during fatigue. Eppinger,[6] Siedeck and Zuckerkandl[43] found more Na than Cl in the morning urine and less in the evening urine. Nonnenbruch[32] came to the conclusion after the observation

of healthy and sick persons, that water is retained in fatigue and is released after rest.

THE ELECTRICAL POTENTIAL OF THE KIDNEY AS A FACTOR IN ITS FUNCTION

In most glandular organs the investigation is concerned with the part that their secretion plays in the various phases of the metabolic processes. The investigators of kidney function, however, are confronted with a problem of more fundamental nature. This is due to the fact that aside from the formation of hippuric acid and ammonia, no chemical transformation occurs in the kidney; the main product of kidney function, the urine, being excreted, plays no further rôle in metabolism. The question here is, how is urine produced from the blood plasma? Therefore it revolves around the problem of the manner in which the cells themselves carry out their work.

The fundamental nature of the problem explains the slow progress made in spite of the large amount of work done. But this very fundamental quality means that progress in kidney research will elucidate not only organ but cell function in general, and success in investigation on the kidney will help to advance research in the activity of living protoplasm. Because we are considering cell function in general and because the interpretation of the findings is based on electrical phenomena, which are explained by showing examples in other glands, one cannot discuss the activity of the kidney without considering other organs and comparing their function with that of the kidney. Comparison of the different types of kidneys in various animals is also of interest and the results are striking, because the micro-electrical properties of the kidney in the vertebrate and of the nephridia in invertebrates are nearly identical, although morphologically these organs are dissimilar.

Experiments with fluorescent dyes have given important clues to the electrical charge of the various cells of the kidney. Singer has shown that the components of the glomerular loops can be selectively stained and on the basis of this staining the different components of the Malpighian body can be delineated according to their electrical properties. The two typical pictures shown here (Figs. 6 and 7) demonstrate how entirely dissimilar is the appearance of the same Malpighian body according to the characteristics of the dye applied. A cathodic substance (acid, positively charged esculine) was applied in the first case, and an anodic substance (alkaline, negatively charged acriflavine) in the second case. The positively charged escu-

line stained the capillary wall, the negatively charged acriflavine stained the glomerular epithelium.

As the presence of fluorescent dyes is detectable in very minute

Fig. 6. Glomerulus in fluorescent light of acriflavine.

quantities, the migration of the dyes could be observed. This is especially the case in Singer's[45] double fluorochroming process, when one positively and subsequently one negatively charged substance are applied to produce fluorescence. By this method one can see clearly how the negatively charged dye passes through the negatively charged cytoplasm on its way to the positively charged nucleus, where it becomes concentrated and stored for a longer time. Special consideration should be given to this fact. By not taking this migration into consideration an erroneous interpretation was given in one of Singer's earlier papers, where it is stated that acriflavine, a negatively charged dye, stains the cytoplasm of the cells.

The speed of the migration appears to be influenced by the electrical charge. From the various substances Singer examined, the

fluorescence of the acid ones (which have a positive charge in the blood plasma) appeared almost instantaneously in the glomerular capsule. The fluorescence of the alkaline substances with similar
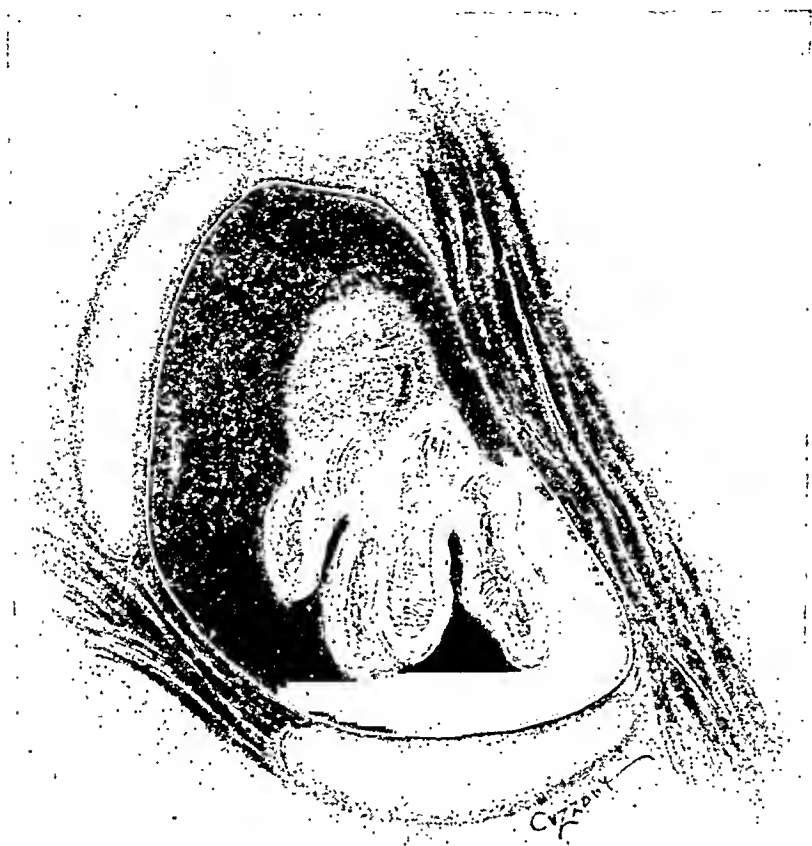
FIG. 7. Glomerulus in fluorescent light of esculine.

colloid dispersion (which have a negative charge in the blood plasma) appeared much later in the capsule and never attained a high intensity in it. Although the appearance of fluorescence is not sufficient for quantitative estimation, since the findings are similar to Fischer's[9] observations on the aqueous humor it would indicate that the mechanism of these seemingly basically different physiologic functions, the glomerular filtration and humor formation, might be the same.

It was observed by Singer, that substances with opposite charge penetrate from the lumen of the tubule into the same cells. The various substances, however, migrated to different parts of the cells. Thus the fluorescent staining of the tubules showed clearly that the cytoplasm of the cells which form the wall of the tubules is

not a homogeneous positive or negative mass. It was seen that the lack of homogeneity is caused by granuli; and the staining experiments with fluorescent substances and with dyes visible in ordinary

FIG. 8. Interpretation of kidney function by fluorescent vital staining. The drawing is a semi-diagrammatic representation of a nephron dissected by Dr. Jean R. Oliver.

light revealed that the proximal convolutions of the tubules consisted of cells having numerous positively charged granuli. The number of the latter gradually decreased so that the distal convolutions contained hardly any. These electrical characteristics of the

kidney cells are in agreement with their functional characteristics as based on microchemical investigations of Richards[37] and his co-workers. (Fig. 8.)
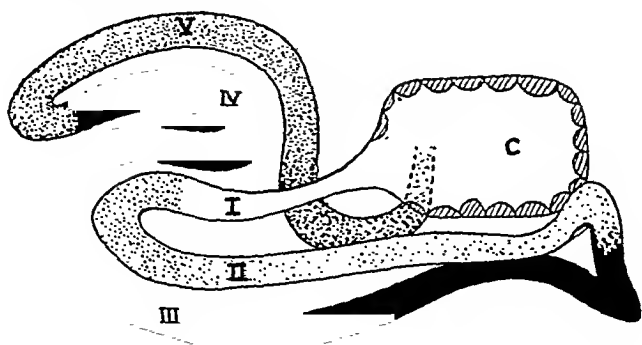
FIG. 9. Segments of the daphnia magna nephridium delineated by vital staining.

The representation of the activity of the kidney cells as shown in Figure 8 (which is based on findings in the mammalian kidney) is strikingly similar to that of Gicklhorn, showing the activity of the daphnia magna nephridium. By the selectivity of vital staining with urotropin-alizarin he could delineate five distinct segments of the nephridial loops. The first segment could not be stained. The second segment stored the dye selectively when the animals were kept in a medium having strong alkaline reaction. In alkaline or electro-positive milieu the dye is relatively negative. The cells of the third segment stored the dye when the reaction of the medium approximated the neutral point. The cells of the loop or fourth segment became stained first and the staining was in this segment the most intensive. The cells of the fifth segment stained only when the medium had a strong acid reaction. In acid or electro-negative milieu the dye is relatively positive. (Fig. 9.) This example illustrates that when working with amphoteric substances a knowledge of the physical and chemical characteristics of the surrounding medium, that is the dispersion phase, is essential. Evaluation of the results of the staining experiments and correct interpretation of the findings can be accomplished only by taking into consideration the influence of the dispersion phase upon the behavior of colloid particles. As the electrical charge of dyes and that of colorless substances depend not only upon the dispersion phase, but upon the concentration, size of particles, and upon other circumstances previously discussed, it is possible that a substance may reverse the direction of its migration. It is of importance to note also that substances with photodynamic action will completely change their behavior after

a short period of illumination (Singer). The changes caused by these influences in the behavior of the substances might explain several contradictory findings of various authors.
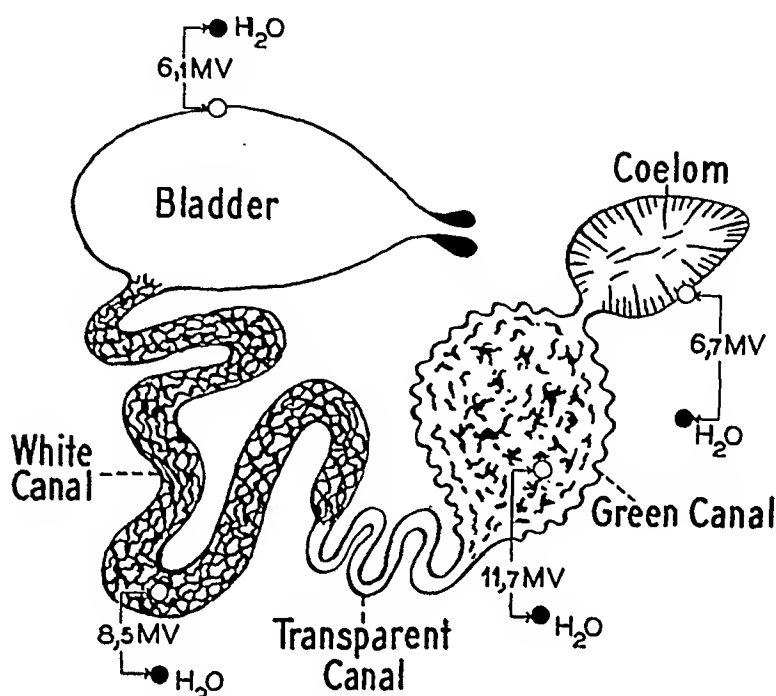
FIG. 10. Schematic picture of the crayfish nephridium showing the electrical potential of its various parts as obtained by microelectrical measurements.

Although one can fit into a general scheme the positively charged substances on one hand and the negatively charged substances on the other, an explanation of reabsorption in the kidney, especially in the proximal convoluted tubules, cannot be based on a simple theory of electrical attraction or repulsion. Quantitative analyses show that the reabsorption is a selective process. To mention one example, all glucose is reabsorbed, but urea is reabsorbed only in part. (Co-workers of Richards[37] found urea crystals in the cells after injection of urea into the tubule as the only evidence of urea reabsorption.) Conceding that glucose is much more negative than urea, as Keller's measurements in high tension apparatus showed, still one cannot neglect the fact that adsorption, chemical reactions, and various other circumstances might play a rôle in the selective activity of the tubular cells.

Potential measurements with micro-electrodes made by Gickl-horn[17] on crayfish nephridium showed a varying negativity of the cells, but also showed that the highest negative potential coincided with the segment in which vital staining was most intensive. This

segment is also the site of the most intensive water reabsorption. The numerical values are shown in Figure 10.

The electrical potentials found by vital staining and by measurements with micro-electrodes are in harmony with the findings on the mineral contents of the kidney. Fischer[9] gives the numerical values as shown in Table VIII. The antagonistic electric groups are

TABLE VIII

ASH CONTENT OF KIDNEY

(Average values in mg. per cent)

	Cl	Na	Ca	P_2O_5	SO_4	K	Mg
	+	+	+	−	−(?)	−	−
Cortex	149	171	12	450	264	411	20
	179	205	13	328	206	422	20
	185	217	14	357	227	410	19
Medulla	284	270	22	192	402	304	4
	402	347	22	199	429	337	5
	398	359	25	194	470	325	5

distributed according to their electrical charge. The cortex, where the positive structures prevail, contains the potassium group; the medulla, where the negative structures prevail, contains the sodium group. Consequently we meet again with the same group distribution of biologically positive and negative substances as we have seen in other organs.

If one compares the amount of the positive and negative groups in the glomerular filtrate and in the urine, one sees that the positive group becomes diluted and the negative group becomes concentrated. (Figure 8.) Sodium is reduced in the distal convoluted tubule to one-twelfth of the amount found in the glomerular filtrate, chloride to one-eleventh, and water to one-fiftieth. The concentration of SO_4 is increased eighty times; that of P_2O_5 six times, K fifteen times, Mg four times, NH_4 150 times (this compound is produced partly by the kidney itself), urea 100 times, creatinine 120 times, xylose 180 times, and glucose in various forms of glycosuria sixty times. Similar changes occur in the concentration of these two groups in the secretion of several other glandular organs.

A comparison between the bile in the hepatic ducts and that in the gall-bladder reveals that the positively charged water is reduced to one-seventh and sodium to about one-third of their previous amounts. The negatively charged mucine and pigments are concentrated eight times, taurocholate nine times, glycocholate eleven

times, fatty acids nine times, bilirubin seventy-eight times. The difference in the concentration of these two groups is less marked between the two types of bile than between glomerular filtrate and urine. One has to take into consideration, however, the fact that the bile in the hepatic ducts is already concentrated by reabsorption of water and chlorine. Comparison between bile in the bile capillaries and that in gall-bladder would show a closer resemblance to the conditions found in the kidney. It is, however, technically extremely difficult to obtain pure bile from the bile capillaries. Keller, in unpublished experiments, succeeded in obtaining pure capillary bile from rabbits; the figures of five experiments show that capillary bile contained respectively 16, 3, 7, 0, and 17 mg. per cent more sodium chloride than bile in the hepatic ducts. Thus the biliary ducts which show identical electrical properties to the distal convoluted tubules of the kidney perform a similar function.

A comparison between milk and blood plasma shows a similar dilution and concentration of the positively and negatively charged substances in the mammary gland. In unpublished experiments, Keller found similar grouping in the distal parts of the ducts in salivary glands, in sweat glands, and in the glands of the intestines. Data collected from the literature show that in most cases free acid wanders in a similar direction with the strong base potassium and the weaker base magnesium or methylene blue. (Table IX.) Exceptions to this rule are found mostly in plant cells (Osterhout[35]).

TABLE IX

POTASSIUM-SODIUM RATIO AND *p*H IN BIOLOGICALLY ELECTRO-NEGATIVE PLACES
(Blood serum K/Na ratio 1:20, *p*H 7.4)

	K/Na Ratio	*p*H
The three salivary glands (Babkin[1])	14:1	6.63
Fundus glands in stomach (Rosemann[39])	2:1	0.88
Sweat glands	2:1	6.90
Mammary gland (cow)	3:1	6.50
Urine (herbivorous animals)	10:1	6.50
IN BIOLOGICALLY ELECTRO-POSITIVE PLACES		
Pylorus glands in stomach	1:4	8.50
Pancreas secretion	1:14	8.6

The analysis of the secretions of glands enumerated in Table IX shows that they are the results of a shifting of the contrasting electrical groups as in the urine. The ducts of these glands consist of electrocytologic structures similar to the distal convoluted tubules

of the kidney. With the similar electrical property goes a similar function. All the glands mentioned reabsorb in their ducts the electro-positive water and sodium chloride and amino acids from the secret fluid in their lumen and by this they concentrate the electro-negative contents of the secretions. Due to the length of the distal convoluted tubules of the kidney the concentration effected by them is higher than that produced by other glands. Thus the function of the distal convoluted tubules of the kidney can be explained by their micro-electrical structure and it can be shown that this function is characteristic of other structures with similar electrical properties. The complicated structure and function of the proximal convoluted tubules, however, cannot be elucidated this way.

THE SOURCE OF ELECTRICAL POTENTIAL

Lund[28] and his co-workers found that those tissues which have the strongest respiration produce the highest electrical potentials. According to Eppinger[6] and his co-workers, lack of oxygen depresses not only the electrical potential of the liver, but also that of the heart, the cross-striated muscles, and the kidney. Kaunitz[19] analyzed the hearts of sixty guinea pigs and found that eighteen were normal, nineteen were under the effect of lack of oxygen, and twenty-three were under the effect of various poisons. In the two latter groups he found heavy losses of potassium in the heart tissue. Due to the effect of lack of oxygen the potassium content declined from 227 to 357 mg. per cent to 153 to 293 mg. per cent. Poisoning with diphtheria toxin, he found, produced a potassium content of 175 mg. per cent, Mg poisoning 143 mg. per cent, and urea poisoning 156 mg. per cent. Kaunitz proved by this that with a definite electrical potential of the tissues goes a certain content of minerals characteristic of that potential.

While several processes thus *depress* the electrical potential of tissues against blood, numerous other processes may *increase* this tension even above normal. Among the chemical compounds which have this effect are digitalis, strophanthin, ascorbic acid (this only in extremely large quantities), quinine, amidopyrine, and novalgine. This phenomenon of increased tension is accompanied by abnormally high potassium content of the liver, heart and muscles. Potassium content of the heart after digitalis increased, according to Kaunitz, to 361 mg. per cent, after novalgine to 326, 317, and 334 mg. per cent.

Some other occurrences observed by other authors should be classified here. Matsuo,[30] who conducted a great number of experiments on vital staining in man and animals, found that patients

during convalescence and experimental animals during the recovery period from various damaging effects showed stronger staining than healthy ones. Keller found, in unpublished experiments on transparent animals (daphnia, cyclops, and paramecium), that vital staining is weak in sick animals and in animals with oxygen deficiency. He also found that vital staining is weak after the application of ammonium salts, whereas the intensity of vital staining increased in these animals after application of quinine, pyrazolon, and various other phenol derivatives. Osterhout,[35] Blinks,[2] and co-workers depressed or increased the electrical potentials of plants according to whether they applied ammonium chloride and oxygen deficiency or various phenol compounds.

Our experiments and the experiments of the above-mentioned authors, especially those of Lund and his co-workers, support the idea that at least part of the energy necessary for the metabolic processes is produced by the electrical potential difference of the positive carbon and hydrogen on one side and the negative oxygen on the other side.

The variation of potassium content in muscle, heart, and liver as shown by Kaunitz indicates that the positive potential of these organs against blood is reduced by oxygen deficiency, by fatigue and by certain poisons; and is increased by digitalis and the pyrazolon group.

It seems plausible that the energy necessary to some phase of the metabolic activity derives from electrical forces. Other sources supply energy to other phases of the metabolic activity. To illustrate this, let us take the liver and muscle as an example.

On the basis of evidence presented we can accept that during the digestion phase the electric current fills the storage places in the liver and muscle. In normal human beings under ordinary conditions this occurs up to midnight. After this time from 1 or 2 o'clock A.M., according to Forsgren's observations,[10] the liver gives back a great part of its glycogen to the circulation. It can be accepted, we think, as a probability, that the electrical potentials are diminishing ·in these hours, and the osmotic pressure of the high carbohydrate concentration in the liver becomes stronger than the electrical counter-force and about 200 Gm. of carbohydrate from the liver, perhaps some also from the muscle stores, return to the serum against the electrical force by diffusion force. It seems plausible that the same counteracting forces might be responsible for the occurrences caused by fatigue, by the effect of toxins, and by oxygen deficiency, and for the other conditions mentioned.

Up to this point we have discussed the way in which the study of chemical changes gives us a key for the understanding of electrical phenomena. There is, however, at least one electrical phenomenon
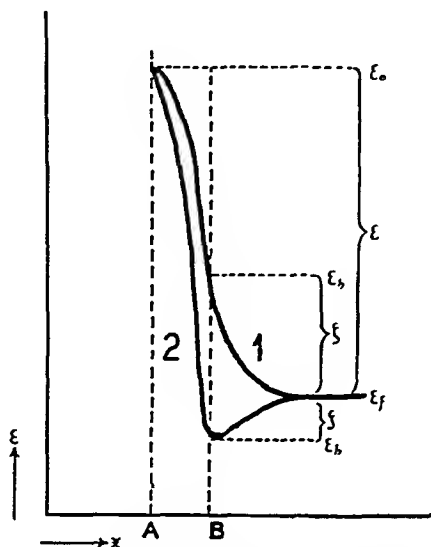
FIG. 11. Potential difference on the border line of a solid wall against the fluid. ϵ, the difference in potential between the solid wall against the movable fluid. ζ, the difference in potential of the fluid adherent to the solid wall against the inside movable fluid. A, the solid wall; B, the movable fluid. Abscissa is the distance of a given point from the wall; ordinates represent the potentials.

in the organism that finds the key to its explanation in a physical process only. This is the contact potential or "Phasengrenzkraft" (Freundlich[11]).

The potential difference that arises when two substances come in contact was observed by Coehn[4] in 1899. He formulated a rule that governs the origin of this potential: A substance having a higher dielectric constant coming in contact with a substance of lower dielectric constant becomes positively charged against the latter. On the borderline of two phases we deal with this type of potential. (Fig. 11.) Part of the static positive charge of the lymph, aqueous humor, and the glomerular filtrate results from this source. This rule of Coehn might be also the explanation for the findings that the glomerulus through which the water is forced by hydrodynamic pressure and the iris of the eye in which the same thing occurs, are, when alive, negatively charged, but lose their negativity after cessation of the blood pressure.

THE MIGRATION OF MINERALS BETWEEN PLASMA AND RED BLOOD CORPUSCLES AND BETWEEN PLASMA AND PARENCHYMATOUS ORGANS DUE TO THE EFFECT OF DISEASE UPON ELECTRICAL POTENTIALS

In the previous paragraphs it was pointed out that the electrical potentials of organs vary with their functional state. Numerous experiments of our own and those collected from the literature were
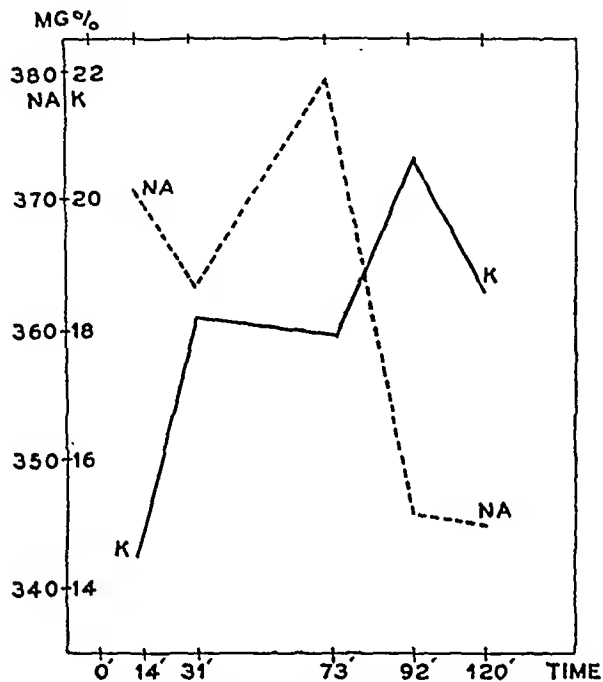
FIG. 12. The migration of sodium and potassium between blood corpuscles and serum during the necrosis of the blood corpuscles in vitro.

cited to support and prove this contention. Reference was made also to the fact that the functional derangements occurring in various diseases affect the electrical potential and cause a shifting in the positively and negatively charged substances.

The shifting of the mineral groups is most characteristic in severe diseases. Waelsch, Kittel and Busztin[55] made several thousand blood corpuscle and plasma analyses in healthy and in sick individuals. These analyses showed that sodium wandered in places to displace potassium and potassium wandered in places to displace sodium. Displacement of minerals occurs also in vitro between serum and blood corpuscle. The manner in which this occurs was studied by these investigators and they found that the equilibrium between these two groups is not a result of a straight progress line, but is subjected to strong fluctuations. The magnitude of the fluctuation peaks is only slightly dependent on the temperature, while the direction of the fluctuation is entirely independent of the tempera-

ture. Figure 12 shows a typical curve of the development of the equilibrium. It is possible that these fluctuations are due to fluctuations in potential difference between red blood corpuscles and plasma that occur during the necrosis of the blood corpuscles. On the basis of this analysis it seems justifiable to consider that the composition of the serum is a result of a mineral exchange between blood corpuscles and plasma which occurs during the clotting process. The composition of plasma in the circulating blood, which would be most important for our interpretation, can only be tentatively estimated. Schmitt's analyses[41] approach the true values closely, because she was able to separate blood corpuscles and plasma by a very

TABLE X

MIGRATION OF MINERALS BETWEEN PLASMA AND RED BLOOD CORPUSCLES
(Values in mg. per cent)

Diagnosis	Plasma			Red blood Corpuscle			Change in Disease					
							Plasma			Red Blood Corpuscle		
	Cl	Na	K	Cl	Na	K	Cl	Na	K	Cl	Na	K
Normal	364.5	310	20.5	254	152	303	0	0	0	0	0	0
Diabetic coma	318	282	21.9	323	134	274	−46	−28	+1.4	+69	−18	−29
Diabetic precoma	315	279	23.3	342	139	266	−49	−31	+2.8	+88	−14	−37
Nephritis with low plasma Cl	307	268	34	324	159	232	−57	−42	+13.5	+70	+7	−71
Chronic nephritis with high plasma Cl	371	309	34	327	160	320	+7	−1	+13.5	+73	+8	+7
Hypochloremia (gastric ulcer)	281	300	27.9	102	62	265	−83	−10	+7.4	−152	−90	−38
Carcinoma of stomach (inoperable)	365	256	40	131	92	262	+1	−54	+19.5	+23	−60	−41
Carcinoma of stomach (operable)	364	280	38	202	74	281	0	−30	+17.5	−52	−78	−22
Polyserositis carcinomatosa	349	151	45	147	68	411	−15	−159	+24.5	−7	−84	+108

rapid method. Table x is calculated therefore on the basis of her findings. It shows a displacement in potassium and sodium content of the blood corpuscles and serum similar to that observed by Waelsch.

Uher[53] examined livers of patients who died from a variety of causes, such as phthisis, general sepsis, pernicious anemia, carcinoma, intoxication, peritonitis, diphtheria, diabetes, and cardiac diseases. The graphs based on his findings show that potassium and sodium change places as in the blood plasma, that is, they wander in

opposite directions to each other. The conditions found in the serum, therefore, reflect the condition of the entire organism. Waelsch found that in severe illness the storage places for the negatively charged substances lose their stored material because the decreased positive electrical charge is not able to retain the full amount and the decreased negative charge of the serum does not repel it. Thus serious illnesses are characterized by a tendency to level the electrical charge and to even the distribution of the antagonistic chemical groups. Waelsch calls this the electrical and chemical dedifferentiation of the organism.

CONCLUSIONS

We have attempted to show in this paper by evidence based on the findings of our own experiments and on data collected from the literature, that lithium, sodium, part of chlorine, part of calcium, and part of magnesium seem to be ionized in living cells. Other substances form non-dissociated macro-molecules in living cells. The charge of these macro-molecules has to be determined experimentally in each case. Thus we cannot divide the radicals of acids and bases into anions or cations, as is possible in distilled water. The division of substances into positively charged and negatively charged groups has to be made according to their behavior in the electric field of biocolloids.

The thin surface membranes or layers of the living protoplasm are able to exert attraction and repulsion forces for both groups and are able to move them in opposite directions. The substances move in the living protoplasm according to their electrical charge. The electrical charge of the various substances as it exists in the living protoplasm, that is in a medium which is rich in colloids, is the decisive factor for their migration. The theoretical electrical charge that one finds with perfectly dissociated salts in distilled water has no bearing upon the behavior of the various substances in living medium. The pH of the various substances as long as they are in physiologic dilutions is of secondary importance to the living cell.

The electrical behavior of living cells plays an important rôle in metabolism and reflects the physiologic or pathologic condition of the organism.

If one acquaints himself with the fact that one has to differentiate between a small group of non-complex-forming substances, that is substances really ionized (dissociated) in living cells, and another large group of complex-forming substances including many minerals, which when greatly diluted in living cells always behave as negatively

charged (anodic) macro-molecules, then one is able to find the confusing mineral tables of the organs readable and comprehensible. The explanation of a great number of physiologic and pathologic processes becomes greatly facilitated by the study of electrical phenomena in microscopic dimensions.

SUMMARY

1. The surface potentials of various substances play an important rôle in cell metabolism.

2. The electrokinetic potential or ζ potential (Freundlich) is of universal importance in life processes. The contact potential (Phasengrenzkraft) plays a more limited rôle.

3. The electrical potentials of organs vary with their functional state.

4. Pyrazolon, digitalis, strophanthin, and natural convalescence show a tendency to raise the electrical potentials to a normal level. Various phenol derivatives raise the electrical potential above the normal level. Narcotics and ammonium salts decrease the potential.

5. Qualitative estimation of the electrical charge can be made by vital stainings. Quantitative measurements have to be made by non-polarizing micro-electrodes.

6. There are two groups of substances; one group is attracted where the positive electrical potential exists, the other group where the charge is negative.

7. The organism contains the two groups according to its electrical potential in its various organs.

8. The electrical groups in living cells which are rich in colloids, have an electrical charge, which has to be found by experiments and must not be confounded with their charge as ions in dissociation in distilled water.

9. In most diseases, in fatigue, in oxygen deficiency, and under the influence of many poisons, the K group (negative group) goes out of the cells and the Na group (positive group) enters into them.

10. The liver is an organ of high positive potential in its parenchymal and reticulo-endothelial cells, and has a high negative potential in its bile capillaries. The blood capillaries and connective tissue in the liver have electrical potentials that are identical with the electrical potentials of these tissues in other organs.

11. Blood corpuscles (positive) and blood serum (negative) have contrasting electrical charges which become depressed in pathologic processes.

12. The secretion of glands derives from the blood serum and lymph. These fluids are rich in NaCl and poor in K. Glands, however, secrete a K-rich and NaCl-poor fluid. This is due to reabsorption of NaCl and water in the distal tubules of the glands. The concentration in the K group is due to the reabsorption of the other constituents of the preliminary gland secrets.

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EDITORIAL

THE RAPID GROWTH OF RECONSTRUC-TIVE SURGERY

THE decision of the Editors of The American Journal of Surgery to devote the whole February 1939 number to "Reconstructive and Plastic Surgery" is a timely one, particularly since this type of surgery, which has developed almost completely within the past thirty-five years, occupies so much of the surgical literature of today.

I was graduated from the Harvard Medical School in 1903, and in that year, Dr. Royal Whitman published his book entitled "Orthopaedic Surgery." This book was considered outstanding in its field, having been written by a man then considered as progressive with regard to operative methods. Yet, an analysis of this volume at the present time is almost startling in that, although it covers the nonoperative orthopedic practice voluminously, operative methods are hardly mentioned. The same can be said of an equally well-known textbook in orthopedic surgery by Jones and Lovett, published at about the same time.

The dearth of operative procedures in existence at that period is also emphasized by a review of the programs of orthopedic conventions held. This is particularly true of the American Orthopedic Association. In all programs from 1900 to 1910, if more than one paper appeared upon an operative subject in a program of a particular year, it was a rarity. On the other hand, one need only glance at the program of a meeting today of this same association, to realize the dominating position that surgery has attained.

The operative work of that period in this branch of surgery consisted almost solely of tenotomies, subcutaneous osteotomies and in tubercular joint disease—merely different types of excision procedure. In infantile paralysis, very little tendon transplantation had been done. Whitman had not even created his astragalectomy operation for paralytic calcaneocavus, deformities of the feet and other conditions.

The only mention that Whitman had made in reference to astragalectomy of that date was that astragalectomy could be done in extreme cases of congenital clubfoot, and he further stated that it is never indicated as a primary operation in childhood, and by no means did he assure the prevention of recurrence of the deformity.

Extra-articular or intra-articular fusion of tubercular joints, including the spine, had not been evolved. The "shelf" operation, or other plastic operations about the hip, had not been born. Congenital dislocation of the hip was treated wholly by bloodless methods. If the hip could be reduced and because of a shallow acetabulum failed to remain in place, there was no operative method suggested to overcome the difficulty. If the patient had reached an age preventing the reduction of the hip because of shortening or other reasons, no method had been suggested of building an acetabulum or socket over the head on the side of the ilium at the most favorable site.

In brief, surgical methods had not arrived for the following conditions: bony stiff joints (arthroplasty to restore motion had not been mentioned); spondylolisthesis; sacroiliac luxation or dislocation. Arthrodesis had been mentioned for the knee and certain of the small joints; but, in 1908, I was the first to offer an operation for arthrodesis of advanced osteoarthritis of the hip and other conditions. There is no mention of any operative procedure for ununited fractures of the neck of the femur, an operation which today is performed so frequently in any busy orthopedic clinic.

The technique of bone transplantation, although fundamentally unaltered since the early days of its inception by the author, is being utilized today in an ever-increasing variety of ways for derangements of the bones and joints. In tuberculosis of the spine and of different joints, particularly the hip, the bone graft is employed for the rapid induction of ankylosis and cure of the disease. The reparative influence of the bone graft enables the reconstruction surgeon to keep pace with the unfortunate sequelae of industrial and road accidents. The therapy of congenital absence of such bones as the radius, tibia and fibula as well as congenital nonunion, can now be undertaken with greater assurance than was possible heretofore. The Albee bone graft spine fusion operation has rendered the treatment of a wide variety of affections of the spine less formidable, including Pott's disease, vertebral fractures, scoliosis, spondylolisthesis and diseases of the sacroiliac joint.

Resection of malignant bone tumors and immediate restoration of the involved tissue by transplanted bone has marked a new achievement for the bone surgeon. The ravages of poliomyelitis have been tempered by the judicious application of arthrodesing and bone block operations. The limitations of tendon transplantation are becoming more clearly defined and a greater reliability reposed when associated with stabilization operations upon the skeleton. My most recent contribution in this field is concerned with the paralytic hip, for which I have devised a method to elongate the lever at the top of the femur for the purpose of obtaining a more stable hip. This operation has also been found to be effective in a number of other conditions where the lever has been shortened, namely, in epiphysitis, congenital dislocation, insufficiency of the trochanter following arthroplasty, and nonunion of the hip with absorption of the femoral neck.

One might make the query—are there any outstanding reasons for the development of such a vast realm of surgery in such a short space of time? The principal reasons for this, I believe, are the development of the x-ray, the bone mill, the orthopedic traction operating table, and, not least, the proof of the wonderful dependability of autogenous bone transferred from one part of the body to another. In a few words, these three decades of pioneer advancement have largely revolved around the various applications of the transplantation of living tissue of which the following are most important: bone, cartilage, tendon, muscle, fascia, subcutaneous tissue and the skin. The development of an adequate surgical armamentarium has played a most important rôle.

FRED H. ALBEE, M.D.

ORIGINAL ARTICLES

PRACTICAL USES OF THE TUBED PEDICLE FLAP

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WHAT IS A TUBED PEDICLE FLAP?

IT is one in which the parallel edges of the long border of the flap have been sewn together leaving at first both extremities undisturbed, like the attachment of a strap to a bag. It thus forms a tubular roll of skin and fat which develops a blood supply from each end.

WHAT ARE ITS CHIEF ADVANTAGES OVER OTHER FLAPS?

The primary advantage of this flap is that whatever the direction of the original blood supply the first parallel incisions cut off all the horizontally inclined blood vessels so that the flap depends only on the longitudinal anastomosis. In the course of three weeks these longitudinal anastomoses enlarge while the horizontal ones atrophy. When, therefore, either end of the pedicle is cut from its bed the longitudinal blood supply now established is adequate for nourishment by one attachment only. It can therefore safely be transplanted without loss from a distant donor site to the requisite area. The donor site can be sutured or grafted.

The secondary advantages of this flap are: (1) Absence of infection and scarring: primary healing of the tubed pedicle flap can be expected in all cases. (2) Flexibility: the tube can be twisted and kinked with a degree of impunity which the non-tubed flap could not stand. (3) Convenience to the patient: irksome positions are inseparable from this class of reconstruction, but the tubed pedicle flap by its length and flexibility markedly decreases the discomfort and duration of hospitalization of the patient. As all wounds are closed a minimum dressing ensures a relief from treatment during the waiting interval. (4) Movability: owing to the ease and frequency with which this flap is attached to the wrist for a temporary blood supply it can be transported from the abdomen quite easily to any part of the body that the hand can approach.

WHEN SHOULD A TUBED PEDICLE FLAP BE USED?

Before answering this question it is wise to consider whether a flap or a free graft should be used in the particular case under consideration. An attempt at a detailed guide will be found in a paper by the author.[1] For practical purposes Table I below may be found useful, but it is not to be taken too dogmatically.

HOW IS THE REPAIR BY A TUBED PEDICLE FLAP PLANNED?

Where the Repair is Confined to the Provision of Skin Covering Only.

Example: Repair of one half of the face excluding the eyelid, the nose, and the lips.

Donor Area: the abdomen.

1. Measure the area and shape of skin required. In making this estimation allow for retraction of displaced normal tissues into their normal position.

2. Cut out in jaconet an exact pattern to fit the estimated raw area caused by the excision of the lesion or scar tissue; corroborate this estimation by turning the

TABLE I

CONDITIONS IN WHICH A TUBED-FLAP IS PREFERABLE TO A FREE GRAFT

Scalp	Complete avulsion with exposure of bone.[1]
Massive Whole Facial Reconstruction	See Figure 1.
Nose	When the forehead flap method is unavailable or undesired. (Fig. 2.)
Cheeks	In large repairs where soft and supple skin is desirable, and when restoration of contour is also a consideration. (Fig. 3.)
Lips and Chin	In certain cases of total loss following excision for disease; and in certain cases of loss of outside covering caused by burn contractures. (Fig. 4.)
Neck	In all severe losses of the skin of the neck the flap method gives a preferable result to even the most successful whole thickness graft. (Fig. 5.)
Front of Chest	In certain cases when a particularly good cosmetic supple effect is required, otherwise free graft.
Back of Trunk	Free grafts are indicated except in the shoulder region.
Upper Limb	The flap method is specially indicated in the repair of arm or forearm. When the burn or burn contraction is very extensive, and no suitable donor area is available, a more conservative method of treating the contracture by free grafts is indicated. In connection with arm repairs a flap is more usually and conveniently applied by the direct method from the side of the body[2] rather than by the tubed pedicle method; but the long thoraco-epigastric tubed pedicle flap as described by Webster[3] is applicable, particularly for large upper arm defects which include the axilla.
Hand	Most defects of the hand from the cosmetic as well as from the functional point of view may be repaired by free grafts. Where the repair, however, may involve opening a joint the flap method is preferable.
Lower Limb	Defects limiting movement of the knee joint and ankle are best attacked by the flap method. The choice often lies between a direct flap from the opposite limb or the tubed pedicle flap method from the abdomen. This is carried down from the abdomen via the wrist. The choice will depend on a number of factors which each surgeon must decide for each case. Where scarring is undesirable on the opposite limb, or where the defect is gross the tubed pedicle method has the preference. (Fig. 6.)

WHAT ARE THE COMMON DONOR SITES FOR TUBED PEDICLE FLAPS?

Oblique Inguinal	This is a very safe flap. No cases of necrosis of a flap of this type can be traced except where it has been grossly maltreated (see Section on Pitfalls and Warnings). As this flap is usually destined for a distant site, such as the neck, one end is transplanted to the wrist which is used as an intermediate host. The special safety of this flap probably depends on the presence of the thoracoepigastric vein.[3]
Acromiopectoral	Another very safe flap. Its base lies below the acromial process and its extremity near the midline of the chest. It is particularly suitable in the male for nasal and other facial restoration. It has better quality skin for facial restoration than abdominal skin, and is sometimes therefore preferred by the female, if she does not wish to wear low dresses.
Scapula Region	This is a favored donor site for the back of the neck and axillary repairs.
Front of the Arm	A satisfactory donor site for facial and nasal repairs except that it leaves a very objectionable scar on the arm.
Vertical Abdominal	This is also an excellent flap with its normal blood supply running parallel with it. It can be used via the wrist for transportation anywhere. Or it can climb by the jump method.
Thoraco-epigastric	This is an extension of the oblique inguinal and is particularly useful in repairs of defects of the upper arm including the axilla.[3]
Vertical Neck	This was at one time popular but has largely been superseded by the acromiopectoral. Apart from the scar in the neck caused by its elevation, it is a very convenient method of transplanting good skin to the lower half of the face.
Many Other Donor Sites	have been chosen for pedicles, but in the vast majority of cases either the common abdominal or acromiopectoral flaps are available. (Fig. 7.)

jaconet over onto the sound side and see whether it corresponds to the estimated loss.

This gives the exact shape and convenient position on the donor site for the flap to be cut.

FIG. 1. A, double tubed acromiopectoral flap. B, primary implantation into face via the wrist. C, flame burns of the face. D, result of treatment.

3. Wet the jaconet so that it adheres to the flap's final destination.

4. Bring the opposite wrist into juxtaposition with the lower border of the jaconet model. (It may be as well to add

It will be noted that the jaconet method of planning constitutes the reverse process of the actual repair.[2] (Figs. 3 and 8.)

Example: Replacement of the skin of the chin and lower half of the cheek.
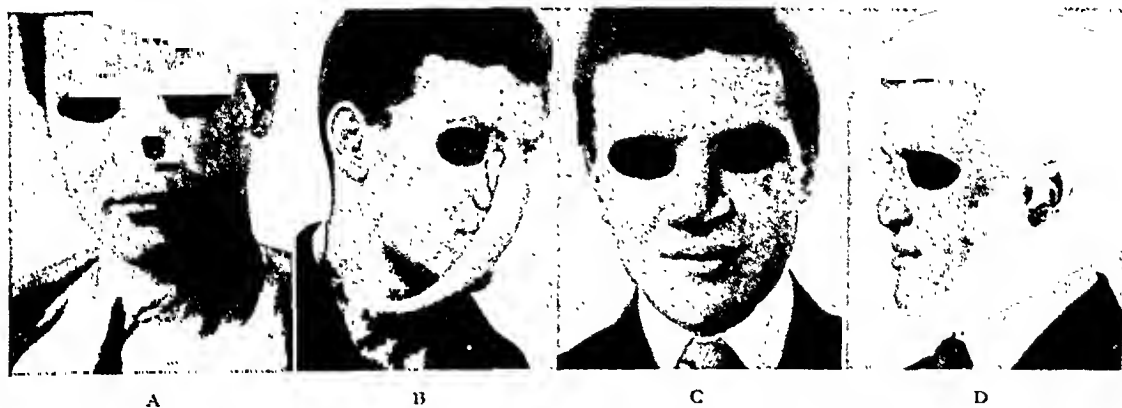
FIG. 2. A and B, total destruction of nose due to congenital lues. C and D, reconstruction by tubed pedicle flap method.

an extra inch to the lower part of the jaconet model in order to have a conveniently mobile pedicle.)

5. Roll the lower half of the jaconet into a tube and place one end onto the back of the forearm near the wrist.

6. Take the jaconet model now held to the wrist down to the abdomen on the same side as the arm and place the untubed part of the jaconet on the outer part of the inguinal region, possibly extending into the lumbar and umbilical regions.

7. Remove the jaconet from the wrist attachment and smooth it down towards the pubis along the inguinal region. Puncture the outline with Bonney's Blue Ink.

Donor Area: the acromiopectoral region.

1. and 2. Repeat.

3. Place the wetted jaconet model so that its upper border lies along the line of the clavicle and its anterior extremity extends no further than the middle line. It will rest in a general direction towards the shoulder. An extra piece forming a pedicle not less than 2 inches broad is continued to a point over the acromial process.

4. Test the position by keeping a finger on the acromial end of the jaconet and raising the patient's shoulder by approximating the patient's hand to the opposite shoulder. Incline the head towards the donor site and confirm that the extremity

of the flap can easily reach the desired position on the chin. (Fig. 4.)

Example: Extensive losses of the neck.

The acromial-pectoral flap is not indicated for this particular repair as it lies too near the region of the repair.

FIG. 3. Massive reconstruction of cheek, nose and lower lip by tubed pedicle flaps. Result five years after final operation.

FIG. 4. Acromiopectoral flap for chin and lip reconstruction.

The method of choice is either an oblique or vertical abdominal tubed pedicle flap transferred to the wrist and carried to the neck. With the patient's hand over the opposite shoulder and with the pedicle attached to the radial border the extremity of the flap can be opened and spread over the defect on the same side as the transporting arm. Fourteen to twenty-one days later, when this half has united to the neck, the pedicle is freed from the wrist, opened and spread around the circumference of the neck. (Fig. 9.)

Alternate methods for the neck are the thoraco-epigastric flap, and the scapular flap running obliquely down the back.

Example: Defects of the axilla and upper part of the arm.

Here the thoraco-epigastric flap is an excellent one and should be better than scapular or acromiopectoral flaps which are taken too near the neighborhood of the joint.

Example: Defects of the anterior chest wall and pectoral region.

The vertical abdominal or the thoraco-epigastric flaps are the most useful.

Example: defects of the thigh.

A long oblique inguinal flap can be designed to give a covering to most defects of the thigh. By flexing the limb the recipient area can be approximated to one or

other of the free ends of the tubed pedicle flap; but an intermediate implantation may be required. To settle this question a

it to the knee. Again the plan should be carefully worked out with the patient's cooperation and a jaconet model.

FIG. 5. A, extensive burns of right half of face and neck. B, result of two pedicles to neck and face, with artificial eye piece. C, neck pedicle prepared on abdomen. D, transfer via hand.

jaconet model of the flap should again be cut and manipulated into its final position. Sometimes an intermediate implantation into one thigh will enable the tubed pedicle to be transplanted to a recipient site on any part of the opposite lower limb.

Example: Defect over the knee cap.

The quickest method, apart from a direct flap from the opposite calf, of transplanting a good covering either to the front or back of the knee joint is by making a tubed pedicle flap of the requisite size on the abdomen, and attaching it to the ulnar border of the wrist as a vehicle to convey

Example: Defects of the ankle and sole of the foot.

When not done by a direct flap from the opposite limb, these defects may be repaired by a tubed pedicle flap carried there via the ulnar border of the wrist.

Example: Massive avulsion of the scalp.

When the bone is not exposed free grafts are satisfactory in this area; but when the bone is exposed it is preferable to cover the raw area of the scalp with a flap. The only flap available is a tubed pedicle flap taken from the abdomen. The design will

include two pedicles which together will cover the area.

The pedicles are planned so as to be

is best done with an acromiopectoral flap, and secondly to form the margin of the helix. For this purpose a long very narrow
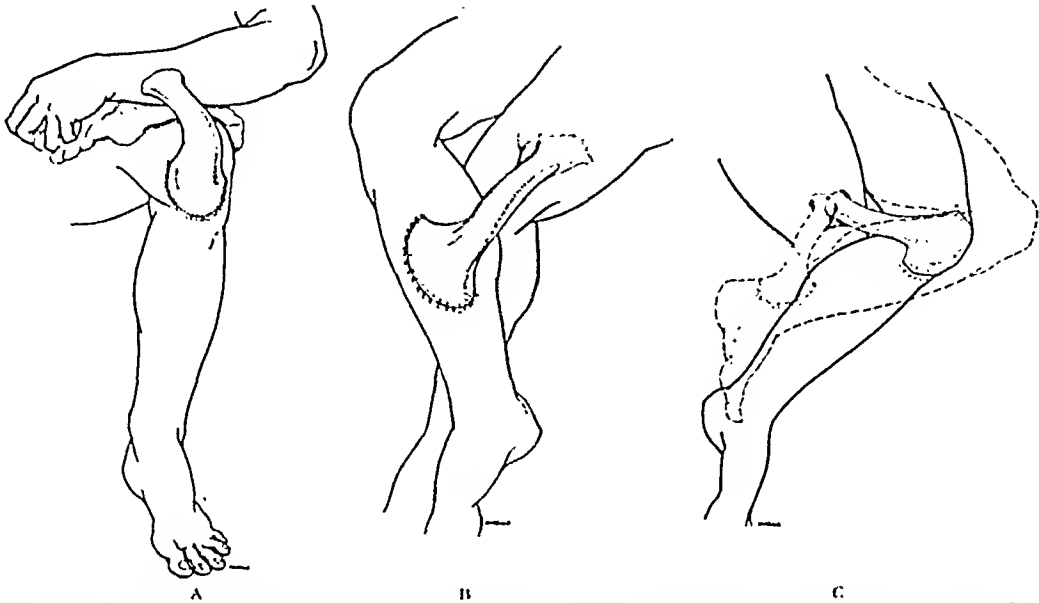
FIG. 6. Use of tubed pedicle flaps for lower limb defects. A, abdominal flap via ulnar border of wrist to knee. B and C, abdominal flap to lower limb with use of opposite thigh as intermediate host.

transplanted via the wrist. After the usual careful measurement two long broad oblique inguinal pedicles are first made. At a second operation these are extended nearly to meet each other in the midline above the pubis. Each of the top ends of the long pedicles is grafted to the ulnar border of the wrist at two separate sittings. As there is extra length of flap to be transported on the wrist, an extra week or two weeks with massage should be allowed before completely freeing the lower end from just above the pubis. The wrist can now be taken with the pedicles which are continuous where they met above the pubis up to the back of the head, and the pubis portion of the flap grafted to the front of the scalp defect. At the end of a fortnight one pedicle can be detached and spread, and at the end of another week the second pedicle may be similarly treated.[4]

Example: Reconstruction of the external ear.

Two uses for a tubed pedicle flap present themselves, firstly to form the covering of the new ear on its posterior aspect, which

pedicle can be made by stages in the neck so that it can be grafted as a free rolled border representing the helix margin.[5,6,7]

Where the Repair Includes Part of the Lining Mucous Membrane.

It must be remembered that in all these cases in which the defects include mucous membrane adequate provision for the lining membrane is even more important than the covering skin. The lining membrane is made by one of two general methods:

1. By grafting whole thickness or thick razor graft skin on that part of the flap corresponding to the mucous membrane loss.[8]

2. By turning in over the area a side branch or prolongation of the flap itself. If the lining has to be made out of the tubed pedicle flap the measurement of the bit required will be double that for the external defect. It should be turned under and the external portion held there by sutures prior to the flap being moved. (Fig. 10.)

Example: Total rhinoplasty by acromiopectoral tubed pedicle flap.

Common measurements for this particular type of flap are 3 inches down the middle line. At the junction between the second and third inch which represents the tip of the nose, the cross line consists of 3 inches, being 1½ inches on each side of the tip representing the free alar margin. A line is then drawn from the extremity of this cross line upward to a point half an inch lateral to the beginning of the vertical line on each side. The line is then continued in a curved fashion at the lower end of the flap round to the opposite end of the transverse line. The total area so marked out is in the form of a sector. (Fig. 11.) The curved portion of the skin below the cross line is destined to be folded in and under to form the columella and lining of the vestibules. (NOTE: It is presumed that a mucous lining is available for the upper half of the nose.) Design a pedicle not less than 2 inches broad running from the side of this flap over the acromial process. Proceed with testing for position as outlined above. (NOTE: It is sometimes advisable to implant a small strip of cartilage from the ear along the line of the alar margin to give support to the new alae.)

Example: Total lower lip reconstruction by acromiopectoral tubed pedicle flap.

Take measurements as before and design flap of such length and size as will ade-

skin graft, preferably of the full thickness variety applied to its posterior surface.

(Suggestion: While writing this paper a
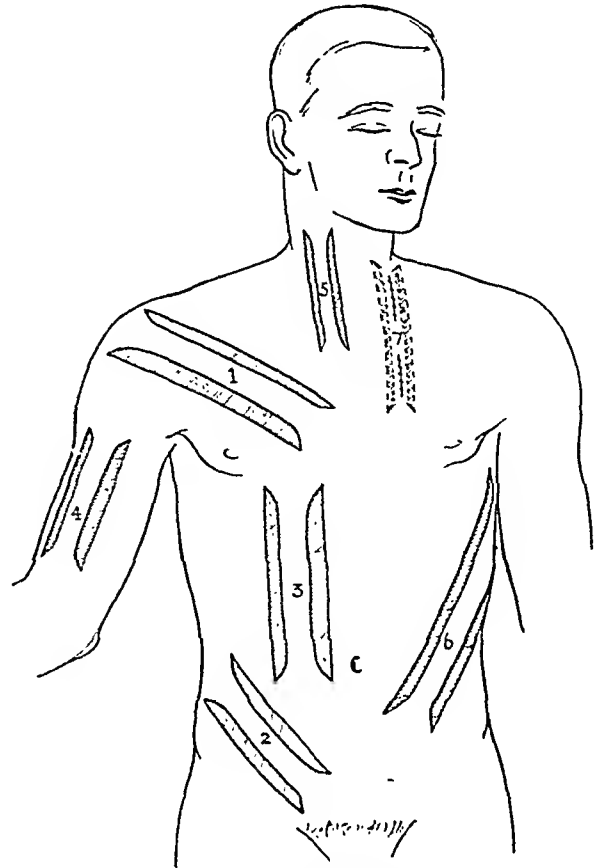
FIG. 7. Common donor sites for tubed pedicle flaps. 1, acromiopectoral and 2, oblique are most common. 7, a scapular flap.

thought has occurred that possibly the reverse process of this type of lower lip reconstruction might be considered, namely

FIG. 8. A, old lupus and extensive radionecrosis. B, transport of flap via wrist. C, result.

quately fill the external skin defect. Plan for the fact that after the pedicle has been made the extremity will be raised and a

to put the flap portion of the repair for the inside of the lip mucous membrane, while the full thickness free graft forms the out-

side of the new chin and lip. This should give a much more everted type of lip than the first mentioned procedure.)

FIG. 9. A, abdominal tubed pedicle flap. B, attachment to wrist. C, first attachment to neck. Note radionecrosis of neck. D, result.

Example: Hypospadias and reconstruction of the penis.

In cases of hypospadias in which there is a definite deficiency of covering skin such as may occur after unfortunate surgical interferences, a tubed pedicle flap forms a certain and safe covering for the ventral aspect of the penis. The lining may be provided by inturned local flaps, or by free graft applied to the under surface of the extremity of the tubed pedicle flap.

GENERAL OPERATIVE TECHNIQUE OF THE TWO COMMON TUBED PEDICLE FLAPS (ACROMIOPECTORAL AND OBLIQUE ABDOMINAL)

First Operation. Outlining the Flap. The jaconet model which has already been prepared has been sterilized with the instruments. The patient's skin should be thoroughly washed with soap and water, and cleansed with alcohol prior to the final cleansing with ether and alcohol on the table. The sterile towels are fixed round the area by painting the skin with mastisol. Local anesthesia, novocaine 1 per cent and adrenalin 100,000, is injected with a Pitcairn syringe throughout the whole area whether a general anesthetic or basal narcosis is used or not. The jaconet model is placed in its predesigned position and dots of Bonney's Blue Ink are punctured into the skin with a needle or sterilized nib around its margin.

Raising the Flap. The jaconet is removed and two parallel cuts are made through skin and fat from one end of the extremity to the other. The width between these parallel cuts must never be less than 2 inches in the acromiopectoral region, or $2\frac{1}{2}$ inches in the abdominal. The length of the flap made at one sitting should not be more than 8 inches. The depth to which the flap should be raised will depend on the fatness of the patient and/or the advisability of transplanting fat with the pedicle for certain repairs. Speaking generally as regards acromiopectoral and thin abdominal flaps, the method of dissection is as

follows: The edges of the flap are picked up with fine hooks and the undermining down to the fascia carried out by dry swab dissection supplemented by blunt scissor dissection. In fat abdomens the flap is raised with an even modicum of fat on its under surface. The broader the flap the more fat can be included with it. In this type the undermining is best done with a knife. All bleeding vessels are clamped, and any persistent ones on the under surface of the pedicle ligatured.

Tubing the Pedicle Flap by Suture. The first suture is usually placed about 1 to 1½ inches from the extremity of the cut at either end. (Note all sutures must be placed so as to include the minimal amount of skin.) A second suture is placed at the other end similarly and these two sutures held in forceps by the assistant who now presents the cut edges of the pedicled flap towards the operator. Either a continuous end-on lightly pulled mattress suture is now passed to complete the pedicle closure,

To assist approximation of these edges beneath an acromiopectoral flap the head may be brought over and the arm raised,

Fig. 10A. Extremity of flap turned under to form lining of new cheek and lip.

and for abdominal defects the knees and back flexed. Three or four deep catgut sutures are used to take the tension off the skin edges and then the edges are approximated by six end-on mattress sutur s supplemented by interrupted sutures. The suture is carried out at each end to a point

B   C
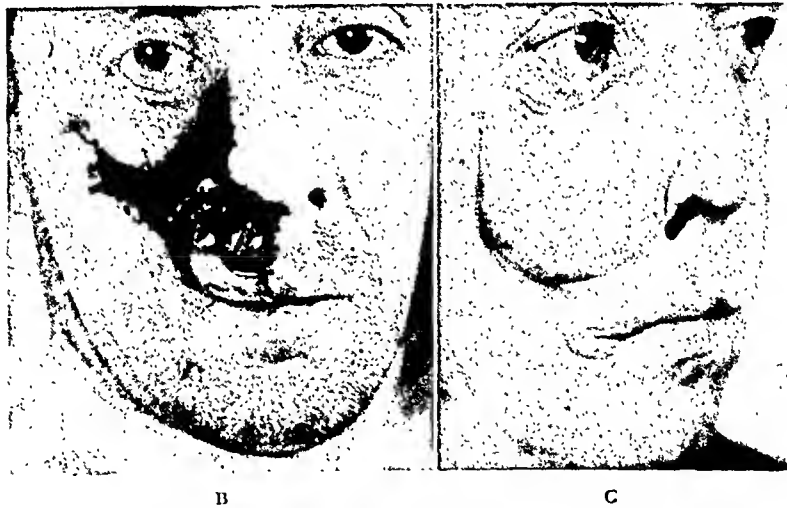
Fig. 10B. Defect following extensive removal for epithelioma. c, result of operation. (Patient referred by Sir Charles Gordon Watson.)

or in certain cases a subcuticular stitch may be used in its place. For a subcuticular suture an eyeless needle is essential and desirable in any case at any time. (Fig. 12.)

Treatment of the Raw Donor Site. Any fat left behind is removed down to the fascial plane, the borders of the defect are freely undermined for a distance of 2 inches or more on either side by blunt dissection.

opposite the commencement of the suture of the pedicle. There will now be revealed a double v-shaped defect, one v on the under surface of the pedicle and the other on the raw surface of the donor site lying face to face. This double raw area is approximated by one comprehensive suture. (Fig. 12.)

First Dressing. The incisions are painted with Whitehead's varnish. To take the

tension off the repaired donor site beneath the pedicle the skin for 3 inches on each side is painted with mastisol and a piece of

Interval Three Weeks. Third Operation. The final abdominal attachment is cut across along the lines of the mark and a
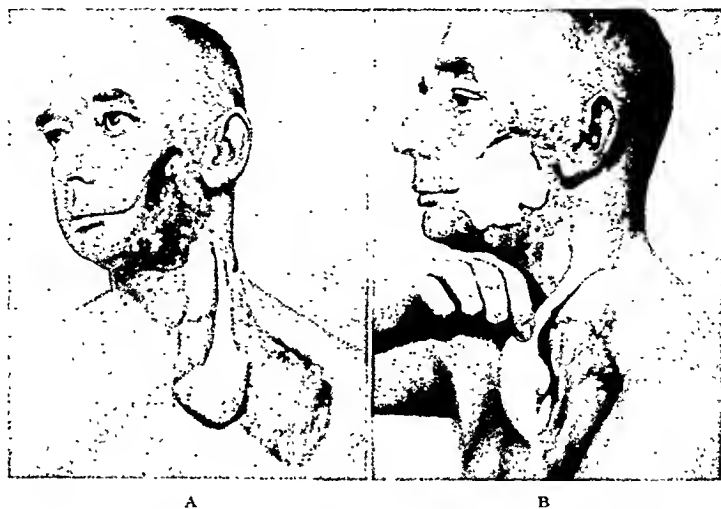
FIG. 11. Example of neck-chest pedicle. A and B, extension laterally turned behind flap to form lining of new cheek.

lastonet applied direct when the mastisol is tacky. To effect this maneuver the pedicle must be held out of the way. Gauze dressings are now applied in such a way as to leave the surface of the pedicle in view and to protect it laterally. The patient is nursed in such a position as to take off all tension from the repaired donor site.

Interval Three Weeks. Second Operation. In an abdominal flap one of the ends of the pedicle is cut across on the original marking and approximated to the radial aspect at the back of the wrist. By pressing the raw surface of the end of the pedicle on the wrist a blood mark will be made of sufficient accuracy with which to judge the incision on the wrist. Half of the blood mark is incised in a circular fashion and turned with its hinge towards the radial border. The raw area on the wrist will now fit the raw area on the extremity of the free pedicle. It should be sutured to the wrist first by two separate stitches at the point where the little wrist flap hinges backwards. Further separate stitches unite the hinged portion of the wrist flap to the pedicle while the pedicle end is sutured to the back of the wrist by a continuous blanket or end-on mattress suture.

special technique employed, in order that as much of the pedicle as possible can be conveniently applied to the recipient area. Not more than half the pedicle should be opened out at this stage and to achieve this two hooks are placed near the central raphe or scar on the under surface of the pedicle and held by an assistant. The pedicle is now held with the left hand underneath it while an accurate and close excision of the central scar of the pedicle, as far as it is intended to open it, is carried out. As soon as the fat is entered the knife is turned laterally on each side and made to follow the circumference of the pedicle. Thus a central core of scar and fat is excised in the process of opening out. The value of the left hand beneath the pedicle is insisted on as by that means alone judgment of the depth of the knife from the skin can be estimated. If an assistant pulls on the scar by forceps, undermining may occur too close to the skin. The flap will now be found to open out into its original design. (Fig. 13.) The arm and flap are now approximated to the recipient area and after suitable excision of scar tissue the flap is sutured into its new home. As there is likely to be a small raw area on the

under surface of the pedicle between where it is opened out and where it is embedded into its new home a small portion of scar

Interval Two Weeks. Fourth Operation. The scar on the wrist is excised and the pedicle freed from the wrist. The same
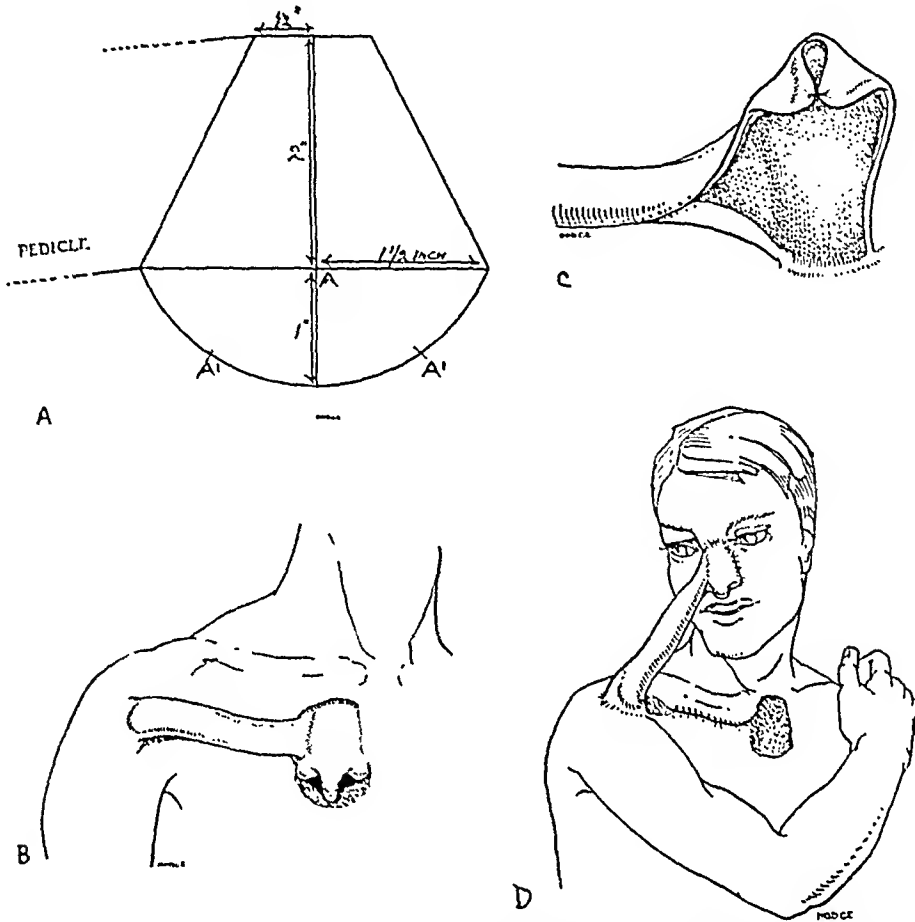
Fig. 12. The plan for an acromiopectoral rhinoplasty. A, pedicle made at first stage. B, pedicle a fortnight later. Lower end of flap turned in to make columella and alae. C, underneath view of this process. D, transference to nose at end of three weeks.
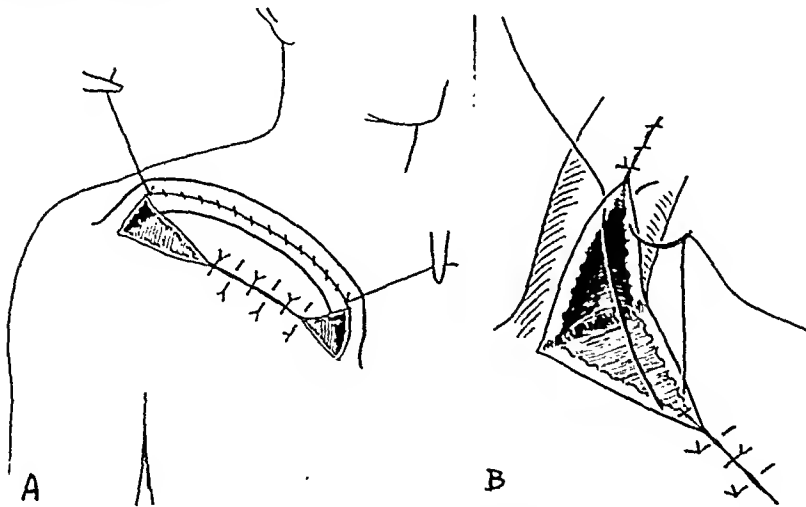
Fig. 13. A, suture of a tubed pedicle. B, special four point suture for opposing raw triangular ends.

tissue removed from the recipient area can be turned backward on a hinge to cover this small raw area and so protect the pedicle from fibrotic changes.

technique is applied to opening the second half of the flap. The wrist is repaired, and the final scar tissue of the defect removed. The flap is bedded into its new position.

Considerable care must be exercised not to interfere with the blood supply of the flap at the junction of its first emplacement and the final portion of the flap.
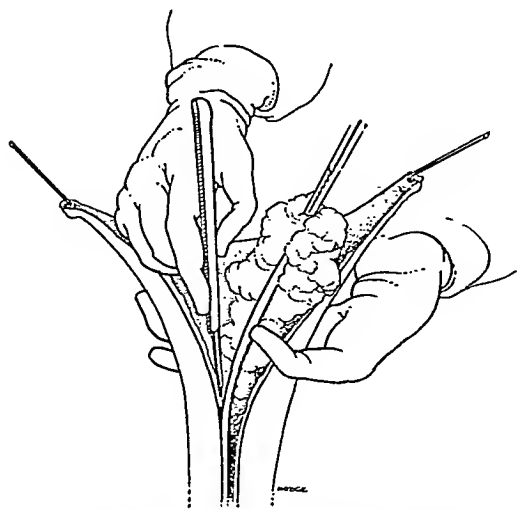
FIG. 14. Technique of removal of central scar and excess fat from pedicle. Note control of depth by left hand behind pedicle.

Acromiopectoral Flap. The operative process is similar but shorter. Frequently however the inner extremity of the flap is required to be broader than the acromial end, as for instance in making a nose. (Figs. 14 and 15.) It is advisable therefore after

for the purpose of getting extra length either at the acromial end of a flap, or in an abdominal tubed pedicle flap the pedicle may be extended at the end of a fortnight. This should not interfere with the plan of dividing at three weeks one end of the pedicle (Stage 2). If, however, the flap is very long an extra week should be allowed.

ACCESSORY TREATMENTS

Fixation. Fixation of a newly implanted end of a pedicle whether this is on an intermediate host such as the wrist or at its final destination, requires elaboration to avoid a sudden movement causing stitches to be torn. Under local anesthetic the coöperation of the patient can readily be obtained, but until the patient is round from a general anesthetic sudden movements must be guarded against. When a wrist, for instance, is the recipient of an abdominal tubed pedicle flap, at the end of the operation the elbow and arm should be strapped to the body side while the hand is fixed to the neighborhood of the groin by strapping passing from the back or front, or both, and encircling part of the thigh.

A   B   C

FIG. 15. A, design for acromiopectoral flap for nasal reconstruction. B and C, result of operation.

the first tubing of the main part of the flap to delay the extremity at a sitting a fortnight after the first operation. The portion "delayed" is the expanded end of the pedicle. At the end of three weeks it may be completely elevated with safety. Similarly

One thus obtains fixation in the two directions in which it is possible to move the arm.

In taking a pedicle up to the neck or face via the wrist the following simple technique has found favor. Mastisol is applied to the

forehead and a surgical cap fitted over the head, the mastisol giving it adhesion in front. The hand or wrist may now be

greatest importance. All joints immobilized by this process should be treated with massage and movements, either passive or
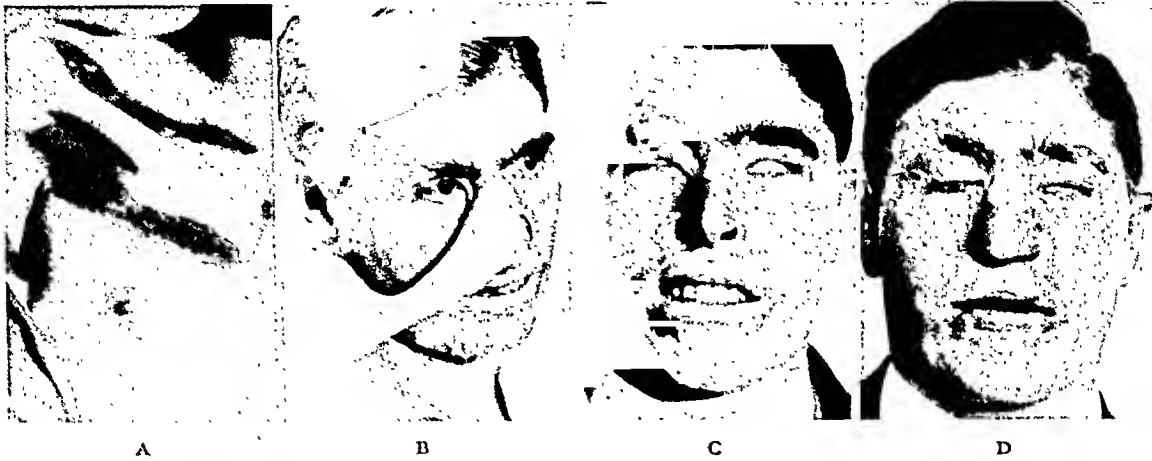
Fig. 16. A, acromiopectoral flap for nasal and upper lip reconstruction. B, intermediate stage of attachment to nose. C, flame burns of face. D, result of flap to nose and upper lip (note also free graft to right upper lid). Case unfinished. Requires free graft to left lower lid and hair-bearing graft to right eyebrow.

strapped to the skull cap in a predesigned position. It will usually be found advisable to strap a small pillow or pad between the elbow and the chest wall so as to keep the point of the elbow up. To prevent the elbow going too far up, strapping can be taken down to the side wall of the chest to preclude movement in this direction.

The acromiopectoral flap sometimes entails a severe inclination of the head and approximation of the shoulder towards the cheek. The fundamental piece of strapping to maintain this position is a circular one embracing the head as previously described and passing round the bent point of the elbow. Care must be taken to see that the flap is not under tension on the one hand or its base of blood supply kinked on the other by too close approximation of the wrist to the face. Subsidiary strapping will probably be required for this adjustment.

Relief of the Irksomeness to the Patient.
1. The extra fixation done on the operation table can often be relieved the next day in suitable patients, and mobility of the wrist and shoulder, elbow and neck, allowed within the limits of the main fixation.
2. Massage and movements are of the

active, at all times during the process of repair. The patient soon learns how much movement is permissible without pulling on the stitches, and within these limits such movements should be encouraged. Frequently a good patient can safely be left with a sandbag as a support for the head, and another for the shoulder, and most of the strapping removed. In difficult
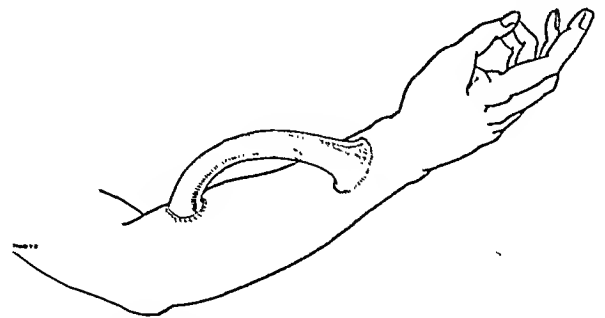
Fig. 17. Both ends of flap embedded in arm for convalescent period. This is occasionally indicated.

positions and with children, it is often worth while practicing the new position of the arm or head for some days before the actual transference is made.

At all times should the mental state of the patient receive the necessary encouragement from those around. All pa-

tients should be urged to get up out of bed at the earliest possible moment. When a large incision has been repaired on the abdomen, however, one must be sure that the closure is firm before allowing the patient to get up. By making suitable alterations in their dress, patients may be tempted to put their clothes on even when their arms are attached by a pedicle to the abdomen. Not only should they get up, but, weather permitting, should go out. In reference to this—when multiple operations must be performed on an emaciated or delicate patient and a rest is definitely indicated, instead of taking the pedicle up to the face when one end has been grafted onto the wrist the other end may be grafted onto the same arm and the patient sent away for a suitable convalescence. (Fig. 16.)

PITFALLS AND WARNINGS

Length and Breadth of Tubed Pedicles. A working rule is that no pedicle at the first operation should be more than 8 inches long by 2 inches in the acromiopectoral region, or 2½ inches in the abdominal region. In thin patients, however, with a good blood supply the pedicles may, if desired, be cut narrower or longer. In fat subjects definite caution should be observed. It is doubtful whether in obese patients the skin has as much volume of blood coming to it as in thin subjects. The same arterial and venous supply is present in both, but in the one has to percolate through a mass of fat as compared with the other.

Crossing the Middle Line. This is always a dangerous procedure and should be guarded against by not allowing the incisions to cross the middle line at the first sitting. At the end of a week it may be perfectly safe to continue the pedicle across the middle line when extra length or width is required.[4]

Placing of the Sutures. If the first suture of each end is placed very near the commencement of the parallel cuts great tension may be produced and the veins occluded at the most important place. An

inch to one and a half inches from the end is the usual safe position. It should be tested manually because it will vary according to the amount of fat which is included in the pedicle. Pedicles have been cut with so much fat that it would be impossible to get their skin edges to join without excessive tension and the fat must be reduced until the edges meet with ease. The exit and entrance points of the suture must be as near the margin of the parallel cuts as possible for two reasons: to avoid stitch marks in the flap, and to prevent contraction of the longitudinal vessels. It is obvious that if a suture is placed ½ from the edge on either side, 1 inch of a pedicle measuring 2 inches is occluded by the stitch, and necrosis is most likely to occur. The best stitch of all for the suture of the tubed pedicle itself is the subcuticular with a fixed stitch at each end, but the end-on mattress and continuous suture are both suitable.

Complications in the After-Treatment. These consist mostly of the advent of a silent hematoma. Small bleeding points can leak into the slack tissue of the tube and fail to make their presence known either to the patient or the surgical attendant. Manual palpation will, however, detect a difference in texture between the skin layers in the presence of a hematoma and it can be easily drained. In connection with the picking up of the vessels, when a tubed pedicle flap is turned inside out to inspect it, there is such a kink on the pedicles that the act of presenting the raw surface to the surgeon stops these small vessels from oozing. Consequently it is better to lift the pedicle up gently without twisting and peer underneath for any bleeding points. It is possible that a pedicle may be squeezed by a too tight dressing or a faulty position.

Necrosis. It must be borne in mind that the operator has no right to risk the loss of any portion of a pedicle flap at any time in its journey. To risk a partial necrosis for the sake of a week or two's delay is surely criminal. Sapiens qui patiens‚

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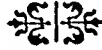
It must be remembered that any stitch which is drawn too tight will defeat its own object by cutting off the local blood supply to the skin edge.

NEW METHOD OF TUBE PEDICLE SKIN GRAFTING

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THOSE who, by severe accident or disease, have been maimed beyond recognition and thus damned to a life of misery, are most urgently in need of skilful plastic surgery. Such deformity means social and economic ostracism, with its inevitable deleterious effect on behavior and character.

In cases such as these beauty cannot be restored. The plastic surgeon can, however, restore normality to the features and make life livable for the unfortunate individual who once again may find his place socially and economically. This cannot be done overnight. The greatest assistants to the surgeon are time, patience, and painstaking labor.

A burned child whose chin is fastened to its chest by a hideous scar, the victim of an explosion whose mouth is no longer human and whose eyelids are turned out of their sockets, the wretched being whose ear has been torn away by a whirling machine, the sufferer whose lip has been destroyed by cancer, a baby born with a cleft in the roof of its mouth—all these victims of ghastly disfigurements can be aided by plastic surgery, for all of these distortions can be relieved by the merciful art of transplanting tissue.

The desire to be normal in appearance is as old as history, and from the beginnings of time those afflicted with a facial disfigurement sought surgical relief to attain peace of mind. Therefore, contrary to popular belief, plastic surgery is not a modern invention. It is true that the restoration of features ravaged by the World War gave a great impetus to this branch of surgery and for the first time brought its more popular aspects to the attention of laymen. But plastic surgery had already been practiced for tens of centuries before the war. Though its early practitioners may have been singularly inept, it is as old as facial abnormality itself.

The Aryuveda, a sacred journal of the ancient Hindus, reveals the fact that marked efficiency in plastic surgery through the use of skin grafts was attained in India more than 2500 years ago. In those days it served a curious cause. A distorted conception of justice provided that the noses of girls of too amorous a disposition or of unfaithful wives might be mutilated by their irate fathers or husbands. Naturally enough, the victims of this brutal law sought the aid of surgeons who, it is recorded, were occasionally summoned by the remorseful fathers and husbands in an effort to atone for their momentary harshness. Thus at first the art of plastic surgery flourished in India mainly to correct nasal disfigurements inflicted in the name of chastity, to help victims of a barbaric law to live again the lives of normal human beings.

Mutilating the nose was also sometimes practiced on prisoners of war. One Indian potentate, a king of Ghoorka, having captured a hostile city, commanded that the noses of all the inhabitants, except those of infants and of adults who played wind instruments, be cut off in order to remind them constantly of his power. The conquered province henceforth was known as the City of Cut Noses.

Because it was apparently effective and easily performed, the mutilation of the nose became eventually a stock punishment for various criminal offenses. It was simpler and cheaper to disfigure a criminal than to keep him in jail. Naturally, this barbaric practice made much work for the corrective surgeons.

These men, forerunners of the plastic surgeons of today, operated in hovels. All around them was filth; Godliness came

Fig. 1. Age 7. Right cheek, temple, and lower eyelid burned in fire. Contracture of scar produced hideous deformity with ectropion of right lower lid downward and outward.

before cleanliness. Their methods, of course, were crude, often brutal.

About 500 B.C., however, after constant experimentation with plants, the technique, later known as the Hindu method, of restoring the nose was developed. This method consists of peeling from the forehead a strip of skin, one end of which is not severed. The strip is twisted so as to keep the outer layer—the epidermis—uppermost. It is then placed over the injured area and shaped to form a nose.

This Hindu method was described by two careful observers in a letter to the Gentleman's Journal, London, for October, 1794. The operation which they witnessed was substantially the same as that evolved so many centuries earlier! Their description is as follows:

"Cowasjee, a Maharaja of the caste of husbandmen, was a bullock driver with the English army in the war of 1792, and was made

a prisoner by Tippoo, who cut off his nose and one of his hands. In this state he joined the Bombay army near Seringapatam, and is now a
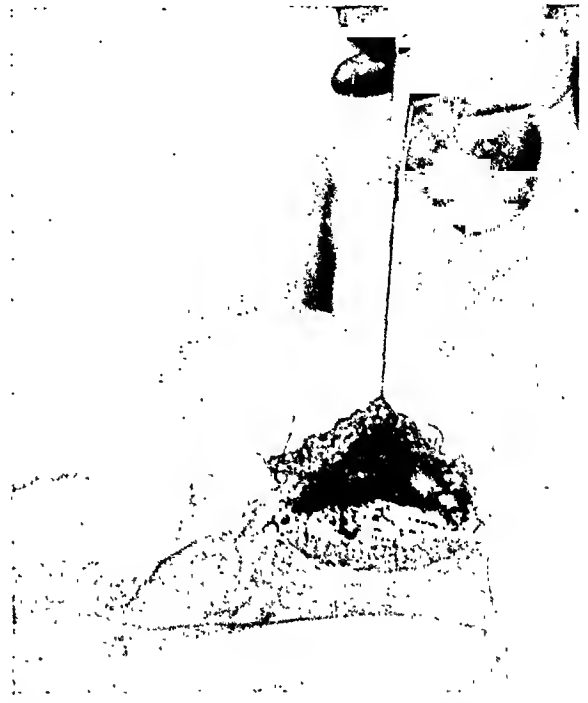
Fig. 2. Same case as Figure 1. Preparation of tubed pedicle from right arm under general anesthesia. Two parallel incisions were made, creating a pedicle separated from the underlying tissues 2½ inches wide and 6 inches long. The pedicle was transformed into a tube with raw surface outward by means of interrupted sutures of silk. Roll of vaselinized gauze used to fill hollow of tube. Wound dressed daily with vaselinized gauze after treatment with metaphen.

pensioner of the Honorable East India Company. For about twelve months he remained without a nose, when he had a new one put on by a man of the brickmaker caste, near Poonah.

"This operation is not uncommon in India, and has been practiced from time immemorial. Two of the medical gentlemen, Mr. Thomas Cruso and Mr. James Trindlay, of the Bombay Presidency have seen it performed as follows:

"A thin plate of wax is fitted to the stump of the nose, so as to make a nose of good appearance. It is then flattened and laid on the forehead. A line is drawn around the wax and the operator then dissects off as much skin as it covered, leaving undivided a small slip between the eyes. This slip preserves the circulation till a union has taken place between the old and new parts.

"The scar of the stump of the nose is next pared off. The skin is now brought down from

the forehead and being twisted half around, its edge is inserted into the raw stump so that a new nose is formed. A little terra japonica is

FIG. 3. Two weeks later, second stage. Proximal end of tube detached from arm, tube unrolled and brought to point of repair of face with interrupted sutures of silk after scar of face was removed and everted lid returned to normal anatomic position on face. Plaster of Paris cast applied to chest and arm to prevent motion of skin flap. Wound treated daily for two weeks.

softened with water, and being spread on slips of cloth, five or six of these are placed over each other to secure the joining. No other dressing but this cement is used for four days.

"It is then removed, and cloths dipped in ghee (a kind of butter) are applied. The connecting slips of skin are divided about the twenty-fifth day, when a little more dissection is necessary to improve the appearance of the new nose. For five or six days after the operation, the patient is made to lie on his back; and on the tenth day, bits of soft cloth are put into the nostrils to keep them open sufficiently.

"This operation is generally successful. The artificial nose is secure, and looks nearly as well as the natural one—nor is the scar on the forehead very observable after a length of time."

It was not until the early Renaissance quickened the imagination of the civilized world that plastic surgery again emerged

into the light. Two Sicilian professors of the art, Branca and his son, have left records of a number of cases of correcting exten-

FIG. 4. After two weeks cast removed, distal end of flap detached from arm, arm brought back to normal position, repair of remaining defect in face completed with distal end of unrolled tube. Picture shows result eight months later.

sive loss of the substance of the nose by using flaps of skin taken from the arm. Though their workmanship was comparatively crude, the results of their operations appear to have been excellent.

It was the Renaissance, however, which produced the true father of modern plastic surgery—the Italian, Tagliacozzi, who developed methods which are still used in correcting facial defects.

A profound student of anatomy and human nature, Tagliacozzi held the chair of surgery at the University of Bologna. Though recognition came to him during his lifetime, his work was constantly impeded by the prevailing bigotry of the time. But to this Renaissance surgeon goes the indisputable honor of having contributed more to the study of restorative surgery than any of his contemporaries. Frequent use of skin from the arm for transplanting to the face is the procedure for which he is chiefly remembered, and this technique is, in his honor, known as the Italian method,

in contradistinction to the Hindu method of using a flap of skin from the forehead.

His methods were imitated by his

Fig. 5. Burn of neck and left arm and axilla from fire, causing contracture of arm axilla and neck.

Fig. 6. Same case as Figure 5. Prepared tube two weeks later. Cylindrical gauze supporting hollow of tube.

students and eventually gained ascendancy in the profession. There were, however, even in his own day, physicians who supported the clergy in opposing Tagliacozzi.

Such men branded him as an impostor and tried to discredit him. After his death his enemies succeeded in blackening his

Fig. 7. Tube unrolled and brought to point of repair after scar of neck was excised. Cast keeps flap immobile. Right arm used because left arm and axilla were also scarred.

memory, and his methods lapsed temporarily. Instead of transplanted tissues, surgeons resorted again to primitive methods for remaking noses, using oilcloth, papier-maché, wood, or silver.

Much that we know of Tagliacozzi's work can be learned from his treatise on "The Surgical Treatment of Mutilations by Grafts," published in 1597, wherein he attributes his discovery of skin grafting to his knowledge of tree grafting. He discusses his method of repairing mutilated lips, noses, and ears, the place from which the skin graft is to be selected, the quantity needed, and the method of joining it to the mutilated parts. Though little was known in his day of the psychology of facial appearance and of the effects of deformity on behavior, he explains, in the introduction to the treatise, that a beautiful face attracts, but an unsightly one fills us with revulsion. He writes: "We restore, repair, and make whole those parts of the face which Nature has given but which Fortune has taken away, not so much that they may delight the eye but that they may

FIG. 8. Result seven weeks later. Linear scar showing attachment of graft to neck still visible.

FIG. 10. Same case as in Figure 9. Showing tube brought to point of repair after preparation similar to that in two previous cases. Cast applied to prevent motion of flap. Right arm used because left arm was also burned.

FIG. 9. Age 10. Face burned in fire, contracted scar producing downward and outward eversion of lower lip and angle of mouth, plus distortion of chin.

FIG. 11. Final result nine months later.

buoy up the Spirits and help the mind of the afflicted. . . . We do this . . . as becomes good physicians and disciples of that great Hippocrates."

European surgeons were informed of the practice of this ancient art in India through a letter to the Gentlemen's Journal already quoted. One of the first to adapt this information to the need of his clientele was J. C. Carpue of London, who successfully performed a number of similar operations in 1814. About the same time C. F. von Grafe in Germany successfully employed both the Italian and Hindu methods. Subsequently surgeons in France and America used the same methods. Ever since, surgeons have been perfecting and adding to the technique of the art of plastic reconstruction.

Thus we see that plastic surgery is probably as old as facial disfigurement. It is true; however, that never before was it practiced on so wide a scale as during and after the World War partly because facial and bodily mutilation exceeded all previous records and partly because surgery had never before been able to cope so adequately with disfigurements.

Those injured in parts of the body other than the face offered the less serious problems, for their scars could be covered by clothing. But many others, with their features shockingly mangled, suffered the tortures of the damned. Fearing to confront the world again with distorted faces, they prayed for death. These men needed speedy relief, if they were to escape irreparable psychic trauma. The surgeons working at the base hospitals on various head specialties united their skill in perfecting old methods and devising new ones to rebuild these ravaged faces.

When the soldiers returned from Europe, their features reconstructed, they were able once more to find places for themselves socially and economically. Such adaptation would not have been possible had their faces still borne the ghastly traces of their experiences in the War.

But times of peace also have their burden of accidents at home, in industry and on the highway and their corresponding need for corrective surgery by the utilization of a skin flap.

Forehead flaps can be modified to suit each individual case. A flap can be taken from the neck or chest, from behind the ear, or from a more distant part, such as the arm, according to the Italian method, or even from the abdomen. But since the skin from these areas has to travel a considerable distance to reach its destination it is best for safety's sake to do these procedures in two stages. An attached transplant from one of these sources is thus given the name of delayed flap.

A new procedure used with delayed flaps was perfected by Harold D. Gillies of London during the World War. To insure the health and success of the flap, he transformed its pedicle into a tube by uniting its edges. It thus nourished itself in its own blood, so to speak.

Though a distinct advance in the art of transplanting skin, the tubed pedicle has the disadvantage of curving on itself while in tubed form and although this tube is unrolled when utilized to cover a defect the tendency for the skin flap to arch a bit remains. Naturally this is more evident in narrower grafts. Here it is a definite disadvantage when a defect of the face has to be repaired because it is difficult to make the arched skin grow flat against the face. In addition, since it is necessary to cut into the fat of the tube in order to flatten it out for use, a certain amount of injury to the tissue takes place in the smaller tubes.

To prevent this tendency for the flap to curl the author has perfected a new technique in skin transplanting by transforming the pedicle into a tube with its raw surface outward instead of inward, the reverse of the Gillies technique. With such raw surface outward the tube cannot grow together, and therefore no curling of the skin flap takes place. Besides, the raw

surface of the graft can be permitted to granulate as much as is desired if a thicker graft is needed, thus obviating additional surgery in the subsequent use of cartilage fascia or fat.

It would appear that a tube with its raw surface outward is exposed to infection, but this is not valid since proper care of the graft, like the proper care of any other tissue in a surgical procedure, will avoid infection.*

The author has used this new method with success since 1933, presenting preliminary reports in 1934 and 1936.

* The interrupted sutures of silk forming the tube can be tied in such manner as to prevent union of the opposing edges of the wound. In such instances the stitches eventually "pull through" and the tube unrolls by itself by the time it has to be transplanted.

THE maxilla is usually fractured by direct violence and this is often accompanied by damage to nasal, malar and lachrymal bones.

RECONSTRUCTIONS ABOUT THE NASAL TIP

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RECONSTRUCTION of the nasal tip has been a subject of surgical interest for at least three centuries. It is a historic fact that the early Hindu efforts (1500 B.C.) to replace severed noses by the well-known forehead flap (Indian) method constitutes one of the earliest chapters in the history of plastic surgery—if not of the general art of surgery itself. In the Middle Ages, when sword fights were the order of the day, a second era of plastic surgery was inaugurated by the celebrated, much-traveled Italian Tagliacozzi, who utilized arm flaps for his reconstructions. The third era received its greatest impetus from the World War and its countless wounded. Interest in the art of rhinoplasty was revived. Hitherto unparalled opportunities were provided for surgeons to perfect old and devise newer methods. The fourth epoch is in the present or automotive age with its countless accidents resulting in crushing and mutilating injuries about the nasal tip.

Intense interest of the present day in this phase, as in all phases of plastic surgery, is a result of the keenly competitive nature of modern life which places a large premium on personal appearance. An enlightened public, moreover, has learned that correctible deformities or even blemishes, whether congenital or acquired, need not be borne through life with "patient resignation." A more enlightened profession is realizing that complexes (inferiority, criminal, etc.) are the sequels. "Patient resignation" without a resultant character or personality blemish is the exception rather than the rule.

Reconstruction of the nasal tip is indicated: (1) in the presence of acute laceration; (2) in the presence of tissue loss (trauma, disease) involving skin covering, nasal lining or nasal supporting structure; and (3) in the presence of cosmetic deformities (congenital or secondary to inadequate or incomplete repair of previous trauma).

Lacerations about the tip of the nose should receive special attention, since the nasal skin, often coarse and filled with large pores, carries potential infection. For this reason, no large suture material should be used due to the frequency of wound infections in this area, as well as the conspicuousness of resulting stitch marks. If such lacerations are sutured with "figure-of-eight" stitches beginning within the nose (thus removing all tension from the wound), the surface need only be approximated lightly with fine horsehair (subcuticular or interrupted) stitches which leave no marks. If preferable or desired, interrupted horsehair sutures with only the first double twist of a surgical knot tied on each stitch may be utilized. If these sutures are removed on the second or third day, no stitch marks should result. (Figs. 1 and 2.)

In motor accidents, glass cuts often sever portions of the nasal skin. Small areas can be replaced at once by a Wolfe graft taken from the upper eyelid or from behind the ear. A lead or tin foil pattern of the lesion should be made and the graft cut to size and denuded of all fat. The graft is then sutured in place with horsehair or small silk, the ends being tied over gauze to produce pressure on the graft. The use of this method necessitates a freshly denuded surface upon which the graft may rest. If pressure is maintained for about eight days most such grafts will take. The patient is thereby saved much delay as well as subsequent operative treatment. (Fig. 3.)

FIG. 1. Lacerations about the nose are common injuries sustained by the guest passenger in the front seat of an automobile due to impact against the instrument panel studded with projecting knobs, gadgets, etc. Note the laceration involving the columella, tip and lower half of the nasal bridge. Nasal skin is so prone to infection that better results are obtained by the use of "figure-of-eight" stitches tied within the nose to remove tension, and horsehair subcuticular stitches on the surface for skin edge approximation. This eliminates stitch marks on the surface.
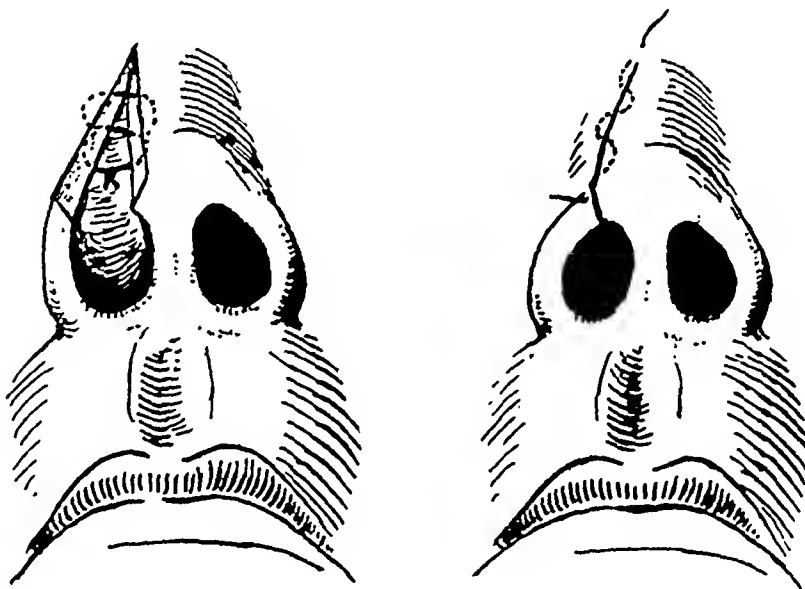
FIG. 2. The use of "figure-of-eight" stitches as illustrated above, to relieve tension in nose, lip, and cheek wounds, helps greatly in minimizing scars from stitch marks. The stitch is started and tied on the inner surface and does not come out on the skin surface. It produces a very close approximation of the wound edge so that a simple subcuticular stitch is often sufficient on the surface.
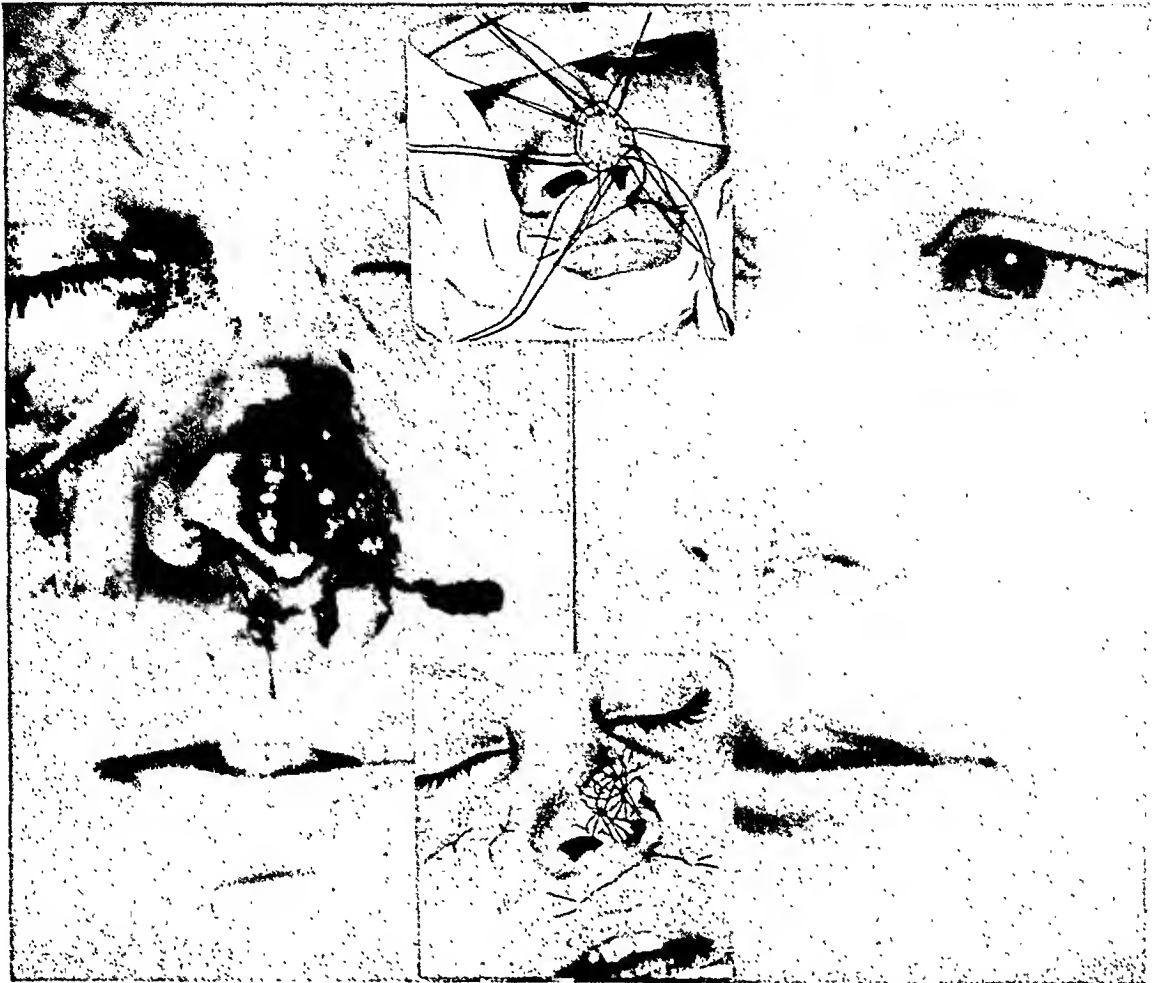
FIG. 3. Loss of skin over the nasal tip due to motor accident. Immediate skin graft taken from back of the ear was sutured in place with fine silk sutures (upper insert) leaving the ends long for tying over gauze pad to produce pressure on graft (lower insert). Note also, subcuticular stitch in upper lip wound to minimize scarring. The graft "took" in its entirety, as shown in after photograph taken some three weeks later.

FIG. 4. Indian method of rhinoplasty. This nose was excised in the treatment of a carcinoma. Insert shows forehead flap transferred to nose and Thiersch graft replacing denuded forehead. After photograph shows the nose following rib cartilage transplant to the nasal bridge and also a support to the columella.

FIG. 5. Author's method of nasal replacement. This nasal tip was severed in an industrial accident. A tube pedicle was constructed on the neck to bring up the skin just behind the right ear (first insert). After two weeks this was attached to the nose and left in place for seventeen days (second insert). Following the severence of the pedicle the tip was reshaped to assume the appearance in the final photograph.
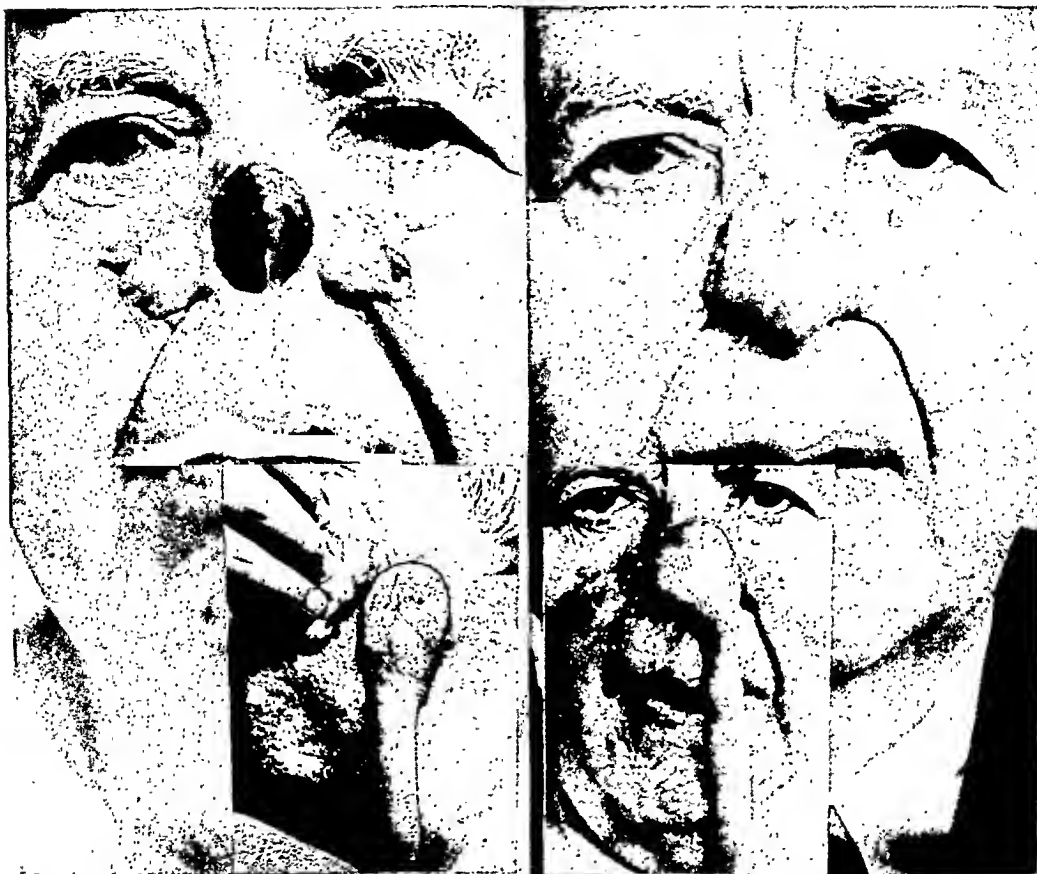
FIG. 6. This nose was severed for the removal of an epithelioma of fifteen years' standing. Lining flaps were outlined on the cheeks and later inverted. Inserts show pedicle before and after transfer to the nose. Final photograph shows result accomplished by this method. The author has used the method in patients from $2\frac{1}{2}$ to 75 years of age, and in both males and females, and finds that the results are very satisfactory.

Fig. 7. Congenital loss of left ala repaired by an inverted flap of surrounding skin to produce lining and covered by an ascending flap from the left nasolabial fold. Note that subcuticular stitches are used to minimize the amount of stitch marking. The final result shows an ala reconstructed of well-matched facial skin and very little secondary scarring.

FIG. 8. A v-shaped piece of skin had been cut from the base of the left ala in an accident. There is a maxim in plastic surgery which holds true with few exceptions, "Never distort tissue to close a defect." In this case the rule had been disregarded and the balance of the ala had been pulled down to the cheek to close the defect. The tip of the nose was deviated and both nostrils practically closed. To repair the loss and supply both lining and covering, a descending flap was elevated and resutured with subcuticular stitches to avoid transferring "second-hand stitch marks" to the nose (upper insert). Two weeks later the ala was detached and the tip of the flap rolled in to supply lining and the surface covered also by the flap (lower insert). The final result shows a well-matched graft and a very slightly noticeable nasolabial scar.

Full thickness losses of the nasal covering demand replacement of both covering and lining and, in some cases, the insertion of

The Italian method (using the arm skin) has the great disadvantage of bringing skin to the nose which does not match that of
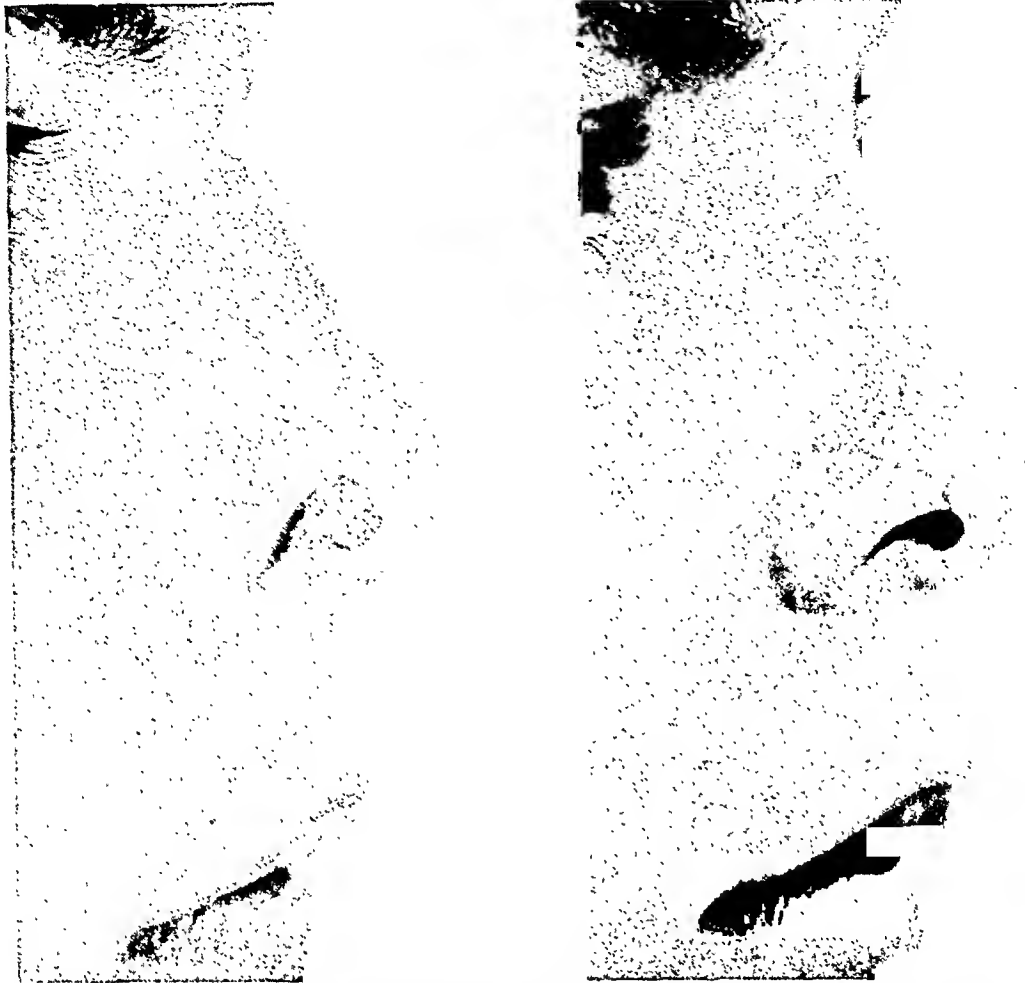
FIG. 9. Small alar deficiencies can be corrected by pedicle transfers from the lateral nasal wall. The above photographs show the correction of a notched ala by a simple z plastic.

supporting material as well. The choice of skin areas for replacement is important. Skin for transfer to the nose should be hairless and, if possible, should closely match the facial integument. These requirements limit the choice of graft material decidedly since skin from other parts of the body will not match that of the face. Forehead skin has been the choice of most surgeons for centuries since it provides ample skin which is both hairless and of good color. It has serious disadvantages in male patients, however, due to the resultant scarred forehead, no matter how nicely the forehead is grafted or sutured. (Fig. 4.) In women, the method is excellent because forehead scars can be readily concealed by the hairdress.

the face. The uncomfortable position which must be maintained for two to three weeks while the arm skin is grafted to the nose, is another serious objection to this method.*

Because of the disadvantages of a scarred forehead as a result of the Indian method

*Franklin Martin, in his book "South America," records an interesting incident regarding Don Pedro de Heredig, founder of Cartagena, Colombia. "Upon a certain night while out bent on a gallant adventure in the narrow and divided lanes on the outskirts of his native village, he was attacked by six gentlemen. These gentlemen so badly impaired Heredig in the affray that he lost his nose and afterwards it was restored by the medium of rhinoplasty, using the fleshy part of one of his arms." The story continues and states that "now cured, but finding his once comely nose deformed and of bad color, Heredig, burning with wrath, sought out his aggressors, challenged them in unequal combat and killed three of them." He relates this as an example of the plastic art in Spain as early as 1520.

and the poor color of the graft when the arm skin is used, I have advocated the use of a tube pedicle from the neck as a means

For smaller areas about the tip or alae of the nose, ascending (Fig. 7) or descending flaps (Fig. 8) along the nasolabial fold are
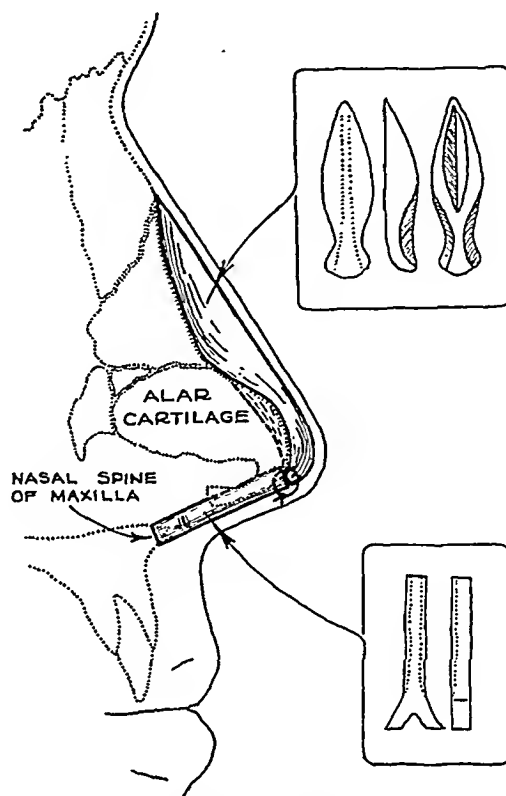
FIG. 10. Rib cartilage, whether autogenous or preserved, should be shaped accurately to give the most pleasing result. The cartilage should be rounded on the top and tip, and usually beveled at the upper end to form an inconspicuous joint at the end of the nasal bone. We undercut the sides of the lower part of the cartilage to permit it to fit over the alar cartilage. The vertical support can be notched at the base so that it will straddle the nasal spine. The two pieces are sutured with fine plain catgut.

of bringing to the nose, skin lying behind the ear and between the scalp and beard hair line. This furnishes skin for facial repairs that matches the face, is practically devoid of hair and leaves only an inconspicuous scar on the side of the neck. This method is particularly useful in males who have a partial loss of the nasal skin or of other areas in the lower half of the face. (Figs. 5 and 6.)

of great value. In each case, however, a lining flap must be provided either by inturned flaps from the surrounding skin or by a free graft applied to the under surface of the flap before it is brought into position.

Loss of the cartilaginous support about the nasal tip is usually due to infections or accident. Lues may cause a septal abscess affecting the nasal tip cartilage, septum, etc., but is more likely to involve the bony

structure and result in a saddle deformity in the upper half of the nose. Complete destruction of the septum and nasal lining

tried, such as ivory, celluloid, paraffin, bone, etc. In my experience, rib cartilage is far superior. The use of this material has

Fig. 11. Typical depressed nasal tip which may be caused by accident, septal abscess or occasionally follow septal resections where no tip support is left. The correction was made by the use of preserved cartilage support inserted through a midcolumellar incision in the manner illustrated in Figure 10.

may cause a complete collapse and inversion of the nasal tip. Intensive antisyphilitic therapy must, of course, be carried out before surgical reconstruction is attempted.

Traumatic injuries to the lower half of the nose may cause fracture of the septum or septal abscess, resulting subsequently in a depressed flat nasal tip. Accidental removal of too much septal cartilage in septum resections when no "post" is left anteriorly, is another frequent cause of nasal tip deformity.

The reconstruction of the depressed nasal tip requires the insertion of some form of support. Many materials have been

undergone an interesting transition. It was first thought that only the patient's own cartilage could be used (autogenous graft); later it was found possible to use cartilage from one person for the repair of a lesion in another (isograft). Since the excellent work of O'Connor and Pierce in preserving human cartilage, it is now possible to preserve cartilage acquired from autopsies (where tuberculosis, lues, cancer, etc., have been ruled out) for months at ice box temperature. This material can be used with little fear of reaction. If infection supervenes, preserved cartilage grafts ap-

pear to be more resistant than autogenous material.

The use of preserved cartilage eliminates the dangers of a rib resection and also vertical post transplant from the maxilla upward to form a solid buttress on which the tip of the horizontal transplant can rest. (Figs. 10 and 11.)

Fig. 12. Bulbous, prominent nasal tips are common deformities. The reduction can be made by careful dissection of the cartilages through intranasal incisions. The above patient had some enlargement of the nasal bridge which was reduced, but the marked enlargement of the tip constituted the greatest deformity. The reduction of this nose produces a very much improved appearance and always adds to the happiness of the patient.

permits one to correct such deformities in children at an early age before they are subjected to the taunts and ridicule of thoughtless playmates.

In slight depressions of the nasal bridge just above the tip, a single piece of shaped rib cartilage can be inserted through a midcolumellar or other incision into a tunnel prepared for it. If a proper splint is applied to prevent hematoma formation, such transplants give excellent results.

Depressions involving the tip require a transplant to support the bridge and

Variations in the form of the nasal tip are numerous. Many of these variations are sufficient to be designated as real deformities. Their correction constitutes a large part of cosmetic rhinoplastic surgery.

Such nasal deformities are due in large part to an overdevelopment of the nasal cartilages. This may result in a very prominent dorsum of the nose (Fig. 12), abnormal breadth of the tip called the "potato nose," excessive length of the nose with an unsightly hanging columella,

or in an overhanging nasal tip. (Fig. 13.) Old fractures may result in a twisted nasal tip.

CONCLUSIONS

The importance of reconstructive surgery of the nasal tip cannot be overemphasized.

Fig. 13. An acute angle between the tip of the nose and the lip is always conspicuous. A long overhanging nasal tip such as the one above can be shortened, changing this angle to about 10 to 20 degrees above a right angle. A much prettier profile is produced.

In all such deformities, the overdeveloped cartilages must be reduced to normal by removing the excessive amount through incisions within the nose so that no scar will result. These corrections bring a great improvement in appearance. Although less formidable than other rhinoplastic procedures, this type of nasal tip surgery is much more exacting, and technically more difficult, than that involving the bony nasal structures.

The nostrils also vary greatly in size and shape. They may be too wide, too long, too short, flat or collapsed. Many of these varied conditions can be altered and improved by plastic procedures.

Such deformities are often very conspicuous and occasionally the only blemish to an otherwise handsome face. The correction of these defects in expert hands now offers very little difficulty for the patient; the danger of infection is negligible and, properly performed, the operations almost always result in a greatly improved general appearance.

The beneficial effect on the mental attitude of the patient is of even greater importance. A comparatively simple operation, performed under local anesthetic, often relieves the patient of a deformity which has been a source of mental agony for years. The counsel of "patient resigna-

tion," too often given by physicians and friends, is unkind and unsound in the light of recent surgical achievements in this field.

The patients, if encouraged to have their deformities corrected, are usually eternally grateful. They soon overcome inferiority complexes and begin their rightful pursuits of happiness.
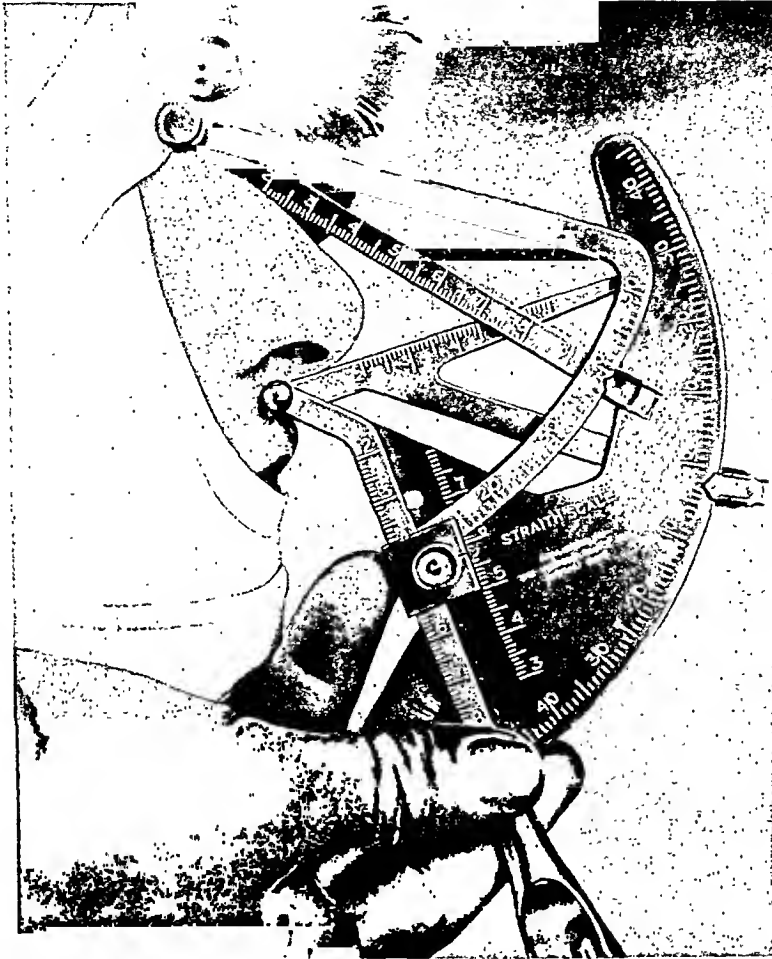
FIG. 14. Author's profilometer: To aid in more accurately reconstructing the nasal contour the author has devised a profilometer which is used in all rhinoplastic operations. The bridge of the nose should project at about 30 degrees from the vertical plane of the face (profile angle). The tip should be tilted from 10 to 25 degrees above the horizontal (tip angle). The length of the nose should be a little less than the distance from the end of the nose to the chin. All of these angles can be measured with this instrument. (In the above illustration the profile angle was 39 degrees, tip angle negative 3 degrees and length of nose 5.8 cm.)

At operation the profilometer is set for the proper angle and the nasal hump reduced to this level. The tip is then elevated and slightly overcorrected to allow for subsequent dropping. By the use of this instrument as a guide, the nasal contour can be "cut down to scale" more accurately than was formerly possible.

REPAIR OF POSTOPERATIVE DEFECTS OF THE LIPS

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PERHAPS no postoperative defects of the face are more distressing to the patient than are those involving the lips. Consider briefly the physical and mental discomfort daily endured by a patient with notable loss of tissue of a lip: his defect will not permit of normal speech; his mouth will not retain adequately either food or water, resulting in insufficient intake of nutriment and fluid, subsequent dehydration, loss of weight and faulty elimination; his saliva drools continually from the opening; his deformity is objectionable to those with whom he comes in contact. Certainly, the closure of such a defect by a plastic procedure, the end result of which is satisfactory from a cosmetic as well as a functional standpoint, is most gratifying to both patient and surgeon.

In this paper, we are not concerned with the etiologic aspects of postoperative defects of the lips; neither do we wish to engage in a discussion as to whether or not the production of all such defects is justifiable. This phase of the subject has been thoroughly considered by Figi and New. Suffice it to say here that the great majority of postoperative defects of the lips are the result of the treatment of malignant tumors by escharotics, irradiation, excision by cautery or electrocoagulation.

New and modified technical plans of reconstruction for the repair of defects about the lips have been and are being developed by plastic surgeons. Although each method may be a well established, satisfactory and systematic surgical procedure, giving excellent results in many instances, no one of these operations is adaptable to every case. So many varying circumstances influence the surgeon in his selection of a particular method to be used in a given case that it is a task of no little difficulty to enumerate

all of them. However, in choosing the most suitable procedure for each individual case, we believe that the following factors should
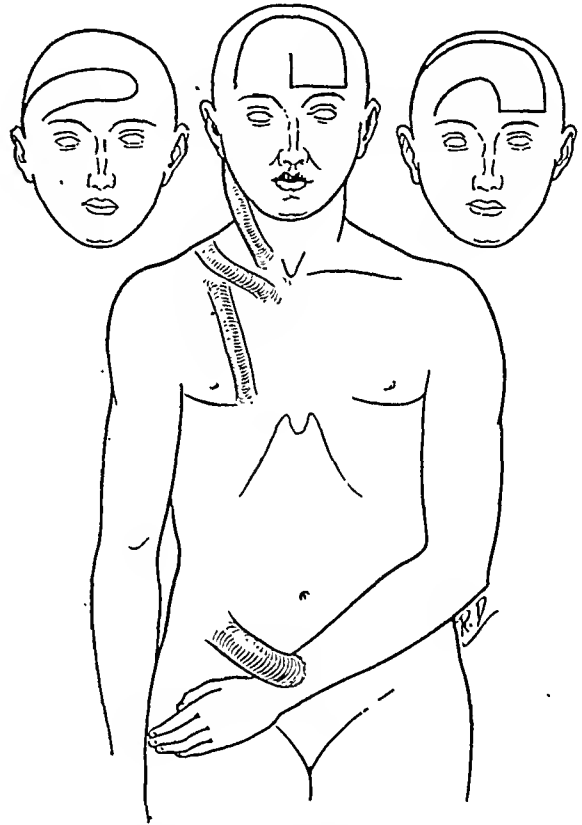
FIG. 1. A diagram to illustrate the types of tubed and delayed pedicle skin flaps used in reconstruction of the lips. A forehead flap may be constructed in one of three ways, as is demonstrated; one crosses the forehead, another contains the supraorbital artery and the third includes the temporal artery. Cervical, clavicular, chest and abdominal-wrist flaps are also shown.

receive thoughtful consideration. First in importance is an inspection of the defect, noting its size, shape and location. Then too, the condition of the adjacent tissues bears close examination; if free from appreciable residual scarring, they frequently can be used for a total or partial reconstruction of the lost part. When of necessity tissues are to be transplanted from a distant source, it is desirable to determine

whether or not the color index and texture of the skin to be grafted will blend with the skin adjacent to the wound. In refer-completed, the surgical method of prefer-ence should be the one that offers the most effective cosmetic and functional result.
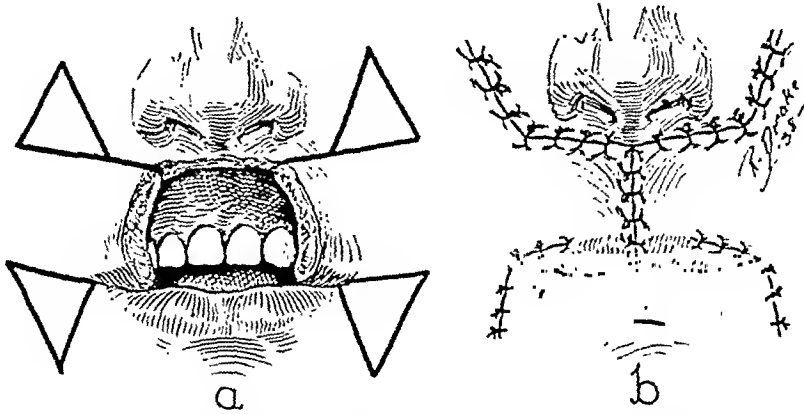
FIG. 2. A method of closing smaller defects of the median portion of the upper lip. After making the incisions indicated in *a* and after removing the four triangular regions of the full thickness of the cheeks, the two lateral flaps can be pulled together and sutured in the median line, *b*, thereby closing the defect.
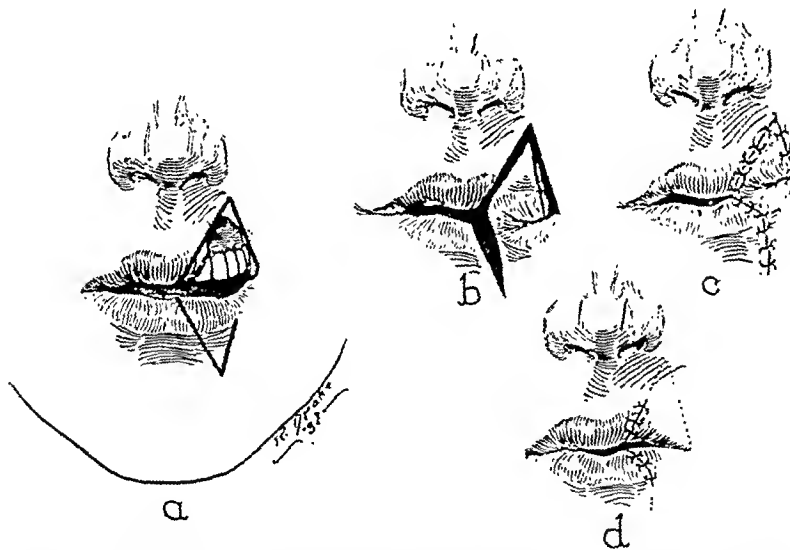
FIG. 3. An Estlander operation, which we use for the closure of defects of the outer portion of the upper lip. A, after freshening the edges of the defect so as to form an inverted v-shaped opening, a triangular flap from the lower lip with a pedicle containing the inferior labial artery is rotated into the defect as in B. When healing is complete with the flap in position C, the pedicle is cut across and the vermilion border readjusted, D.

ence to the patient, the age, sex, mental and social status and general physical condition are of significance. The length of time required to complete various plastic procedures is of consequence in relation to the patient's financial position. In a final analysis of the situation, after an investigation of the foregoing factors has been

Generally speaking, the closure of a defect of one or both lips can be effected by reconstructive surgery in one of two ways: either by the rearrangement of the tissues adjoining the wound so as to rebuild the lost portion or by the transference of skin from a distant part of the body to the defect by means of a tubed flap or a delayed

pedicle dermal flap as used by Blair. Since those methods of reconstruction which employ the adjacent tissues are so numerous

along or near the clavicle; (4) the chest tube flap, which usually occupies a vertical position and is always situated to one side
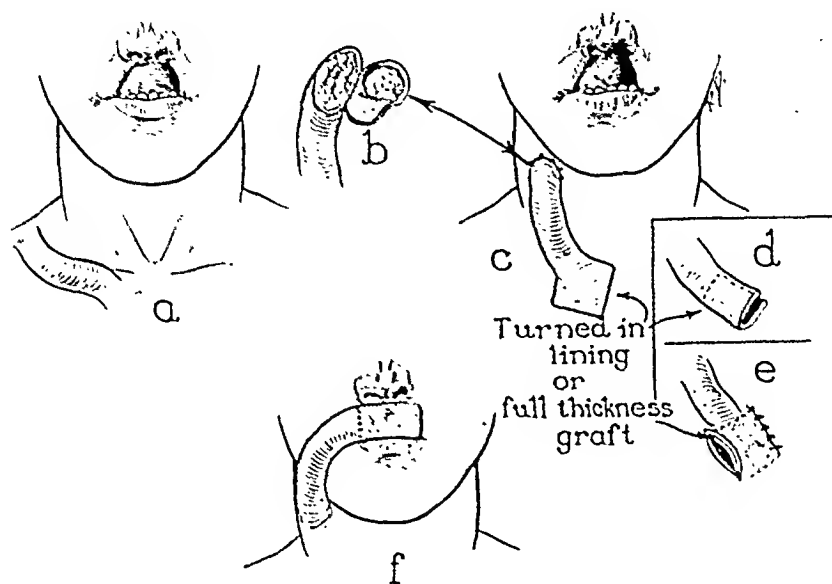
Fig. 4. A method of reconstructing the upper lip in men when there is considerable loss of tissue. A clavicular tube flap of skin is utilized and the position of this flap in the right clavicular region is indicated in A. The lateral end of the tube is transferred to the right midcervical region. In this attachment B and C, a semicircular flap of cervical skin is turned down; the lateral end of the tube is then sutured over this turned-down flap and over the bed from which it has been elevated. The mesial end of the tube, which is to be used for the reconstruction, is outlined C; this end must be lined with skin in one of two ways: either by folding or turning in the skin, D, or by lining the mesial end of the tube with a full-thickness skin graft, E. The mesial end of the tube is brought up and sutured into the defect, F. After healing has occurred, the unused portion of the tube is discarded and, if desirable, flaps of mucous membrane from the inner surfaces of the cheeks can be moved across to form a vermilion border.

and often so intricate, it is not possible to show all of them in one comprehensive drawing. However, we have attempted to demonstrate, somewhat diagrammatically, in a single sketch all of the pedicle flaps which we use when it is desirable to transfer skin from a distant portion of the body to the defect. (Fig. 1.) There are five such flaps, namely: (1) the forehead flaps, which may be so constructed as to take the form of a horseshoe using the supraorbital artery, a flap following the course of the temporal artery on one side to the frontal region of the opposite side or a flap running across the forehead; (2) the cervical tube flap, extending from the mastoid tip, along the sternocleidomastoid muscle to the sternoclavicular articulation; (3) the clavicular tube flap, which passes transversely

of the median line in its entirety; and (5) the abdominal-wrist flap, which consists of an abdominal tube flap derived from the skin just above the groin and attached to the wrist of the opposite side. (Fig. 1.)

REPAIR OF DEFECTS OF THE UPPER LIP

Since the upper lip is an uncommon location for the development of malignant neoplasms, postoperative defects are encountered rather infrequently in this region. Occasionally, in very small defects of the upper lip an acceptable closure can be obtained by surgically trimming the opening in such a fashion as to form an inverted v-shaped wound, the margins of which are sutured together. However, such a procedure, even in conjunction with a plastic operation at the angles of the

mouth, is most unsatisfactory in defects of any appreciable size because of the fixation of the soft tissues at the base of the nose.

FIG. 5. A method of reconstructing the upper lip in men, employing a cervical tube flap. The lower end of the tube is transferred directly to the upper lip so as to fill the defect. It is lined with skin by either one of the methods shown in D and E of Figure 4.
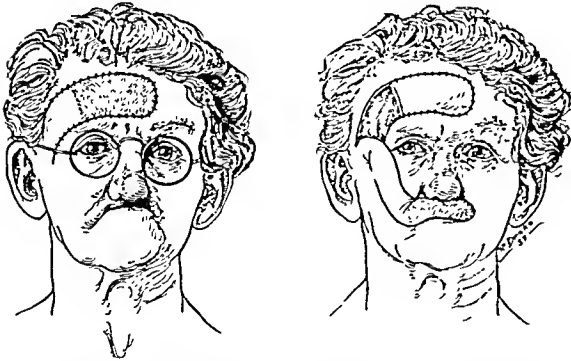
FIG. 6. A method of reconstructing the upper lip by means of a forehead flap. This is the method of choice in women. As is indicated by the shaded area, the distal portion of the pedicle is lined with a full-thickness skin graft. The flap is brought down and sutured in position, while the region on the forehead left denuded of skin is covered with a full-thickness skin graft obtained from the arm. (From New and Figi, in *Surg., Gynec. & Obst.*, 62: 182, 1936.)

Small defects involving the central portion of the upper lip can be repaired by

moving flaps of the full thickness of the cheeks across to the median line. (Fig. 2.) This is a rapid method of closure and one
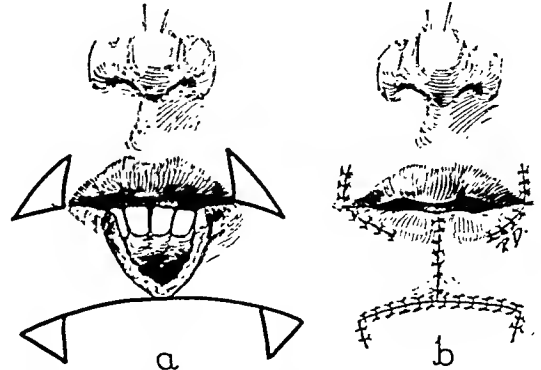
FIG. 7. A method of closing a defect of the mid-portion of the lower lip. The technique of this method is identical with the procedure illustrated in Figure 2. In preference to this method, we usually close such defects by the operation shown in Figures 8, 9 and 10.

FIG. 8. A method of closing larger defects of the lower lip. The edges of the defect are cut so as to form a v-shaped opening. A triangular portion (not including the mucous membrane, which is incised only at the base of the triangle) of the upper lip and cheek is removed from either angle of the mouth. Small triangles of vermilion margin, *x*, are removed on either side so as to produce a straight mucocutaneous border. (From New and Figi, in *Surg., Gynec. & Obst.*, 62: 182, 1936.)

to be recommended, since it can be completed in a single stage. Providing the loss of tissue is confined to the middle third of the lip, this procedure offers less ultimate difficulty than does an Estlander operation. However, if there is fixation of the tissues adjacent to the defect due to postoperative scarring, which would interfere with the mobility and elasticity of the cheek flaps, then an Estlander operation would be preferable.

The principle of an Estlander operation consists in the transference of a wedge of tissue from the normal lip to the defect of the opposite lip. This operation is a par-

ticularly effective method of closing a defect of the outer portion of the upper lip. (Fig. 3.)
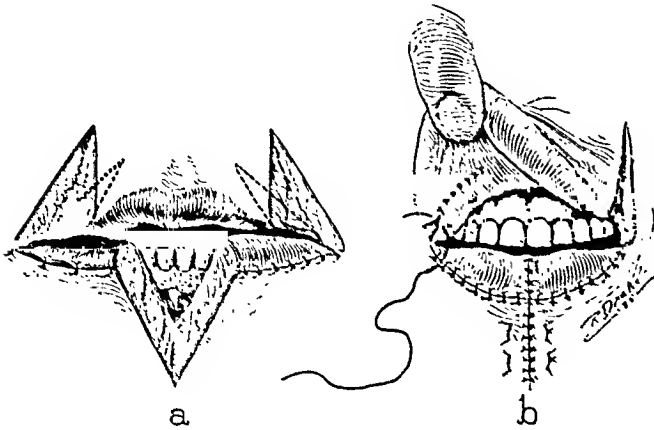
Fig. 9. A, wedge-shaped portions of mucous membrane are removed as illustrated by the dotted lines; this allows the angles of the mouth to roll inward. B, the raw edges are sutured, using black silk for the skin and catgut subcutaneously and for the mucous membrane. (From New and Figi, in *Surg., Gynec., & Obst.*, 62: 182, 1936.)

When the greater part of the upper lip has been lost, the resultant deformity is best corrected by means of a pedicle skin flap taken from a distant region of the
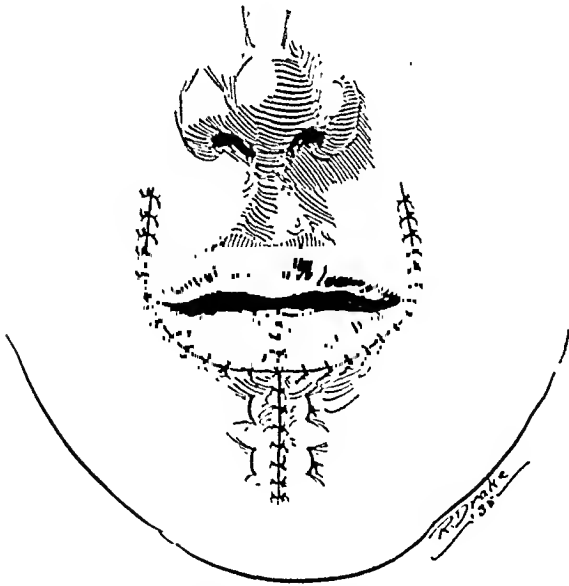
Fig. 10. Completion of the procedure demonstrated in Figures 8 and 9. (From New and Figi, in *Surg., Gynec. & Obst.*, 62: 182, 1936.)

body. In the construction of an upper lip, a clavicular tube flap (Fig. 4), a cervical tube flap (Fig. 5) or a delayed forehead flap (Fig. 6) may be utilized. Probably, a flap which crosses the forehead with a pedi-

cle in the temporal region (Fig. 6) is the simplest type of forehead flap to employ in reconstructing the part under discussion.
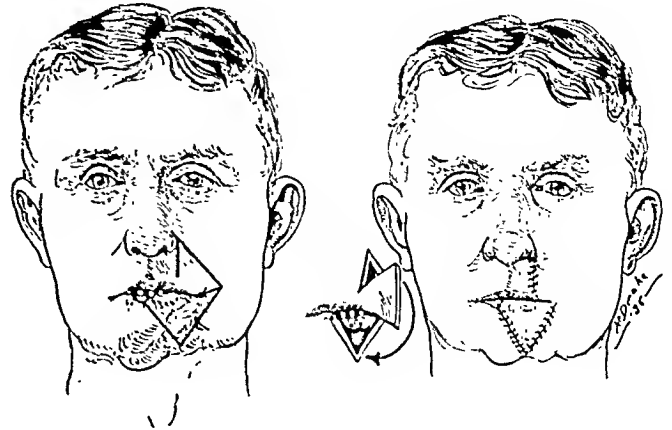
Fig. 11. An Estlander operation for closure of defects involving the outer portion of the lower lip. A wedge-shaped flap with a pedicle containing the superior labial artery is elevated in the upper lip and rotated down into the defect below. (From New and Figi, in *Surg., Gynec. & Obst.*, 62: 182, 1936.)

Such a pedicle flap must be elevated and delayed before it can be transferred to the defect; with each successive stage of elevation, more blood vessels to the flap are severed, which, in turn, physiologically increases the vascular supply in the pedicle. After the skin flap, so prepared, has been conveyed to and sutured around the margins of the defect (and this applies to any type of skin flap), we allow a period of ten to fourteen days to elapse before partially incising the flap to reduce the blood supply from the pedicle. Then with the passage of another six or seven days, the grafted portion of the flap will have developed an adequate vascular supply from the margins of the defect so that it can be entirely freed from its pedicle.

The technique of using a clavicular tube flap for reconstruction of the upper lip is well illustrated in Figure 4 and the cervical flap in Figure 5. In the preparation of a clavicular or cervical tube, the flap of skin is elevated and tubed at the initial operation. After a period of one to two months, the end of the tube to be utilized is partially cut across, elevated and sutured back in its original position. After another seven to

ten days, the entire end of the tube may be detached and transferred. We wish to call attention to the method (Fig. 4B) of

ment of an adequate blood supply from the point of intermediate attachment.

A clavicular or a cervical tube flap should

FIG. 13.

Skin surface

Raw surface
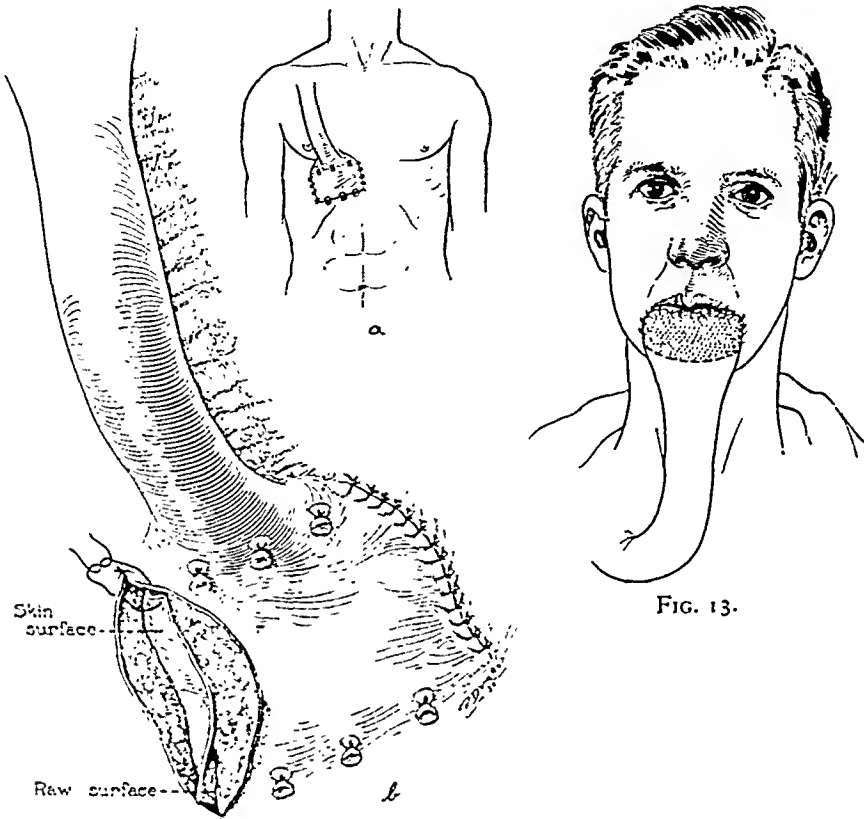
FIG. 12.

FIG. 12. Method of reconstructing the entire lower lip by means of a chest tube flap. a, position of tube flap on anterior portion of thorax. b, lower end of flap which is lined with a full-thickness skin graft.

FIG. 13. The lower end of the chest tube flap is elevated and sutured in position to form the new lower lip. The shaded portion indicates the lining formed by the full-thickness skin graft. (From New and Figi, in *Surg., Gynec. & Obst.*, 62:182, 1936.)

connecting the clavicular tube to the neck during its migration to the upper lip. This is a particularly satisfactory attachment and is conducive to rapid healing. Moreover, there is no loss of the cervical skin by this procedure, which permits of a perfect closure of the wound on the side of the neck after the tube has been removed. Subsequent to the transference of one end of the tube as an intermediary step, as has been described above, three weeks are allowed to pass before attempting any work on the other end of the tube; this three-week period is necessary for the establish-

be so constructed that the skin in the region of the sternoclavicular articulation may be employed for the reconstructed portion of the lip, because the color index of the skin in this location is very nearly the same as that of the skin of the face.

Regardless of what type of skin flap is used, that portion which will form the new lip must be lined with skin. In a forehead flap, this is best accomplished by applying a full-thickness skin graft to the under surface of the flap during the period that the latter is being gradually elevated. A clavicular or a cervical tube flap may be

lined in one of two ways: either by folding the end of the tube or by using a full-thickness skin graft. (Fig. 4.)

upper lip, the question at once arises as to which type of flap should be employed. This is largely dependent on the sex of the
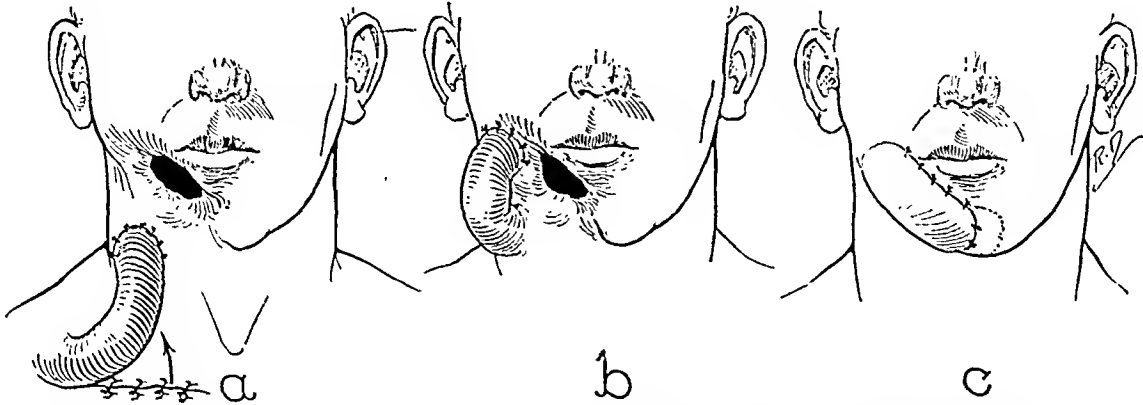
FIG. 14. Closure of a large defect of the lower lip and cheek below the vermilion border by means of a clavicular tube flap. A, the mesial end is transferred to the right midcervical region. B, the lateral end is elevated and sutured to the posterior margin of the defect. C, the mesial end is removed from the cervical region and attached to the mesial margin of the defect. Some of the fat in the tube is tucked under the mesial margin (indicated by the dotted line) in order to give the proper fullness to the chin. Later the superior and inferior surfaces of the tube are incised and sutured to the corresponding margins of the defect. Since none of the fat in the tube is removed, a well-rounded contour is obtained in the reconstructed region.
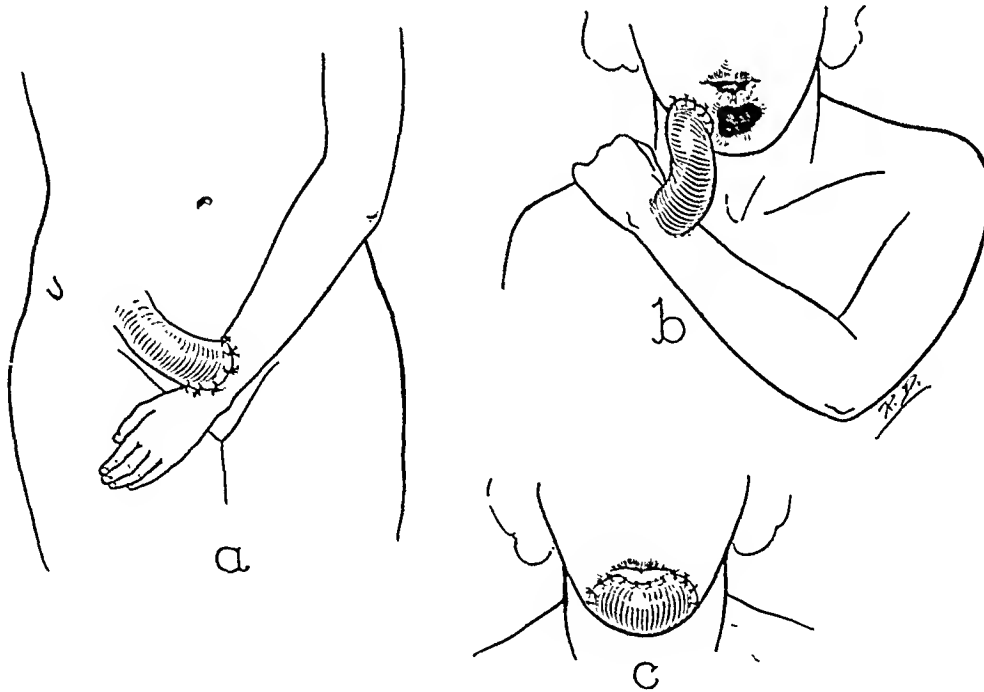
FIG. 15. The repair of a defect of the lower lip below the vermilion margin by means of an abdominal-wrist tube flap. A, a flap of skin just above the groin is elevated, tubed and its mesial end is attached to the wrist at the first stage. B, the lateral end of the tube is cut across and on elevation of the arm it may be sutured to the one margin of the defect. C, the other end of the tube is severed from the wrist and is sutured to the opposite margin of the defect. Later the superior and inferior surfaces of the tube can be incised and sutured to the corresponding margins of the defect. By this method, the tube forms not only the covering but also the lining for the reconstructed part. The fat in the tube gives a normal contour to the chin.

In cases in which it is decided that a skin flap from a distant part of the body is necessary to reconstruct a portion of the

patient. A forehead flap is perhaps the simplest and quickest method to use but this procedure does leave a denuded region

on the forehead which must be covered with a skin graft. In patients with thin skins, the color of such a graft generally

FIG. 16. Small defects at the angle of the mouth may be closed by excising two triangular portions of the full thickness of the cheek, one above and one below the defect. Suturing the edges of this diamond-shaped wound closes the defect.

will eventually blend nicely with the surrounding skin of the forehead. But in patients with thick skins, pigmentation may take place in the graft which will stand out in marked contrast with the normal skin of the face. Then too, with the use of a forehead flap, some residual scarring in the frontal region is unavoidable. Consequently, in men, the use of a forehead flap is to be discouraged, but in women, who can and will alter their hairdress so as to cover the frontal region, a forehead flap is the method of choice. A few women greatly dislike the thought of a scarred forehead or neck and in such patients an abdominal-wrist flap should be utilized. It is well to remember that regardless of the sex, if the forehead previously has been scarred, the use of a flap in this region is usually out of the question. At times, however, a flap with the temporal artery extending well into the hairline and coming down to a usable area of the forehead may be employed.

A forehead flap is indicated in male patients only in those who are not concerned with the cosmetic result. Otherwise, a clavicular or a cervical tube is the best type of skin flap to use in reconstruction of the upper lip in men. Of these two types of tube flaps, a clavicular flap is usually preferable because it is larger and offers more tissue which can be used for con-

structing the lip. However, less time is required to build an upper lip by means of a cervical tube flap; it has sufficient
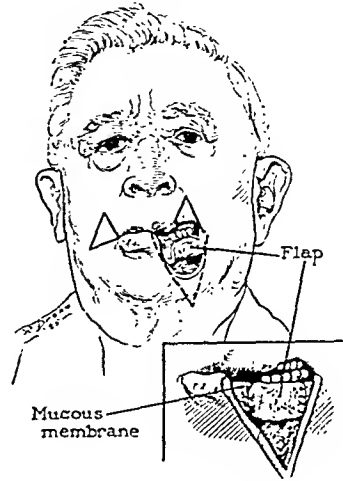
FIG. 17. A defect involving the angle of the mouth and an adjoining portion of the lower lip can be frequently closed in the manner illustrated here. A flap of skin at the lower margin of the defect is turned up to form a lining and is sutured to the mucous membrane of the lip on one side and to the mucous membrane of the cheek on the opposite side. Then by removing the triangles of tissue from the upper lip and cheeks at each angle of the mouth, the skin edges of the defect, which are cut in the form of a v and which are deeply undermined, can be brought together over the flap to close the defect. (From New and Figi, in Surg., Gynec. & Obst., 62: 182, 1936.)

length so that its lower end can be elevated directly to the upper lip (Fig. 5), while a clavicular flap is so situated that its outer end must be first transferred to the neck before its lower and inner end can be transferred to the face. (Fig. 4.) The use of a cervical tube entails the disadvantage of leaving on the side of the neck a scarred line which is difficult for the patient to conceal entirely.

REPAIR OF DEFECTS OF THE LOWER LIP

Providing there is little discernible scarring or fixation of the tissues to the

mandible, small defects of the lower lip may be removed by shifting flaps of the full thickness of the cheeks over the opening.

tissue can be advantageously procured through the use of a chest tube flap or an abdominal-wrist flap, either of which will
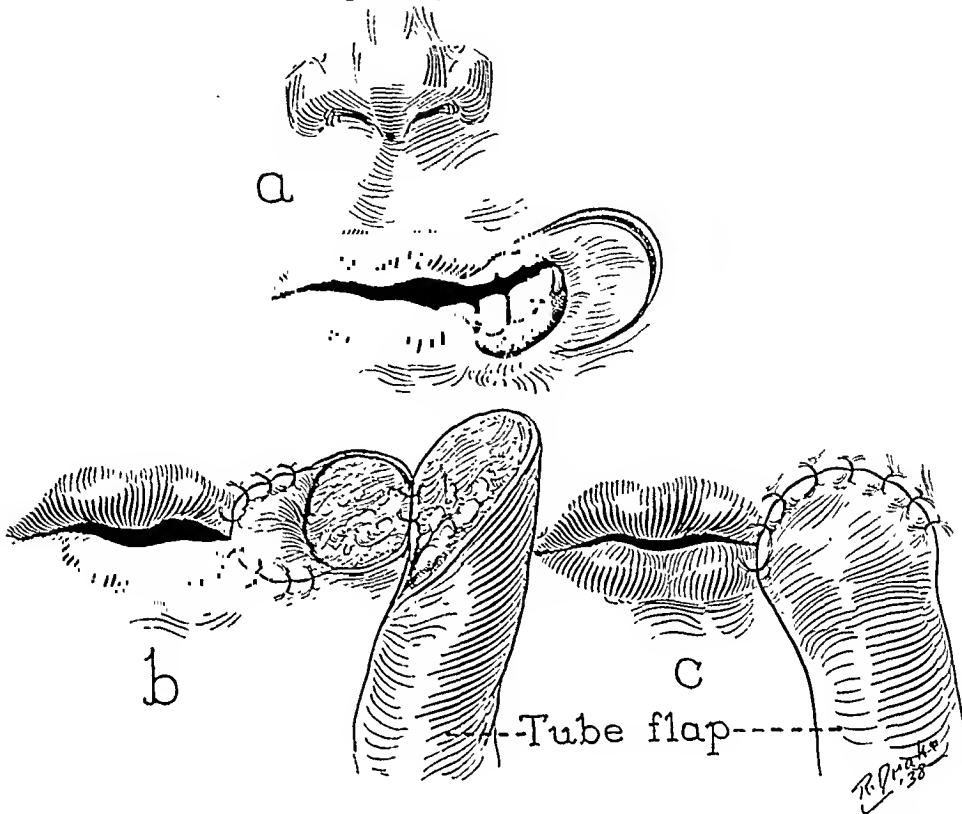
Fig. 18. Closure of a defect at the angle of the mouth by means of a tubed skin flap. A, the lining may be constructed by turning a flap of the adjacent skin into the wound and suturing it to the mucous membrane edges of the wound; B, the end of the tubed flap is then sutured over this flap and over its former bed to cover the defect.

(Fig. 7.) However, we believe that in most instances it is a better practice to convert such a defect into a v-shaped wound, the margins of which are sutured together; this results usually in a greatly narrowed oral aperture, the width of which can be adequately increased by a plastic procedure on the upper lip and cheek at either angle of the mouth. (Figs. 8, 9 and 10.) A slight modification of this has been made by Marino. The end result of this method is most satisfactory both from a cosmetic and from a functional standpoint, even though the defect may include the greater part of the vermilion border. When a notable loss of tissue exists at the outer portion of the lower lip, an Estlander operation is an effective method of repair. (Fig. 11.)

Complete loss of the lower lip demands a plastic reconstruction of the part; sufficient

supply an abundance of skin for the restoration. When using a chest tube for such a purpose, the flap must be made relatively long from end to end and large in diameter. Consequently, a great deal of time is necessary for a proper blood supply to be established in such a tube. After the primary operation in which the chest flap is elevated and tubed, it is best to wait about three months before its lower extremity is raised. Either end of a chest tube flap may be employed to form the new lower lip. (Figs. 12 and 13.) Since the color of the skin in the clavicular or infraclavicular regions resembles more closely that of the face than does the skin over the lower part of the chest or abdomen, the upper end of a chest tube flap is beneficial to use from a cosmetic point of view. However, its use incurs one disadvantage, namely that of extending the

time necessary to complete the plastic procedure, because the lower termination of the tube first must be transferred to the
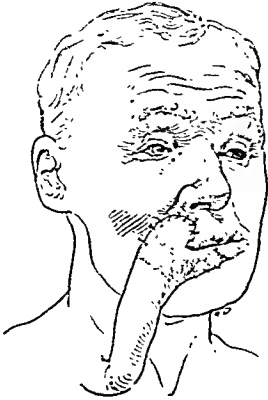
FIG. 19. Closure of a defect at the angle of the mouth by means of a tubed skin flap. The dotted region indicates a full-thickness skin graft forming a lining for the reconstructed portion. (From New and Figi, in *Surg., Gynec. & Obst.*, 62: 182, 1936.)

neck before the upper part can be elevated to the face.

Owing to its shortness, an abdominal-wrist flap offers a rapid means of reconstructing the lower lip. At the initial operation, the necessary amount of skin is tubed and the mesial end is sutured to the wrist. Only three weeks are required before the distal end can be partially incised and within a total period of about five weeks the tube can be elevated to the defect. In preference to an abdominal-wrist flap, Webster advocates the use of a long tube extending from the inguinal region to the axilla and including the thoraco-epigastric vein; the great length is necessary so that the lower end of the tube can be swung directly to the facial defect. However, we feel that just as much can be accomplished in considerably less time by the use of a short abdominal tube attached to the wrist.

By employing either a chest or an abdominal-wrist flap, an excellent lower lip can be constructed. The factors deter-

mining which type should be used for the restoration are essentially the color of the skin to be grafted and the duration of time required to complete the plastic operation. The best cosmetic result can be obtained by the use of the skin at the upper extremity of a chest tube flap, while the lower lip can be built in the shortest amount of time by means of an abdominal-wrist flap.

Regardless of which tube is used, the portion which is to form the lip must be lined with skin. This can be accomplished by folding the end of the tube, or better by the use of a full-thickness skin graft. (Fig. 12.) A vermilion border to the lip may be constructed by sliding flaps of mucous membrane from the cheeks across the upper free margin of the graft.

Large defects of the lower lip below the vermilion border can be filled in by tissue obtained from a clavicular, cervical, abdominal-wrist or chest tube flap. The use of the last-named tube is hardly justifiable since by any one of the other three methods, an effective closure can be completed in much less time. The problem to be considered in repair of the defects under discussion is the large bulk of tissue necessary not only to close the defect but also to build out the normal contour of the chin. In short, fat is needed as well as skin in most of these cases. All of these requirements can be met by first attaching one end of any one of the mentioned tubes to a lateral margin of the defect; later the other end of the tube is fixed to the opposite lateral margin of the opening; and finally the superior and inferior surfaces of the tube are incised and sutured to the corresponding margins of the defect. (Figs. 14 and 15.) Since none of the fat is removed by such an attachment, a well-rounded contour is obtainable in the reconstructed region. If a large mass of tissue is required for the restoration, an abdominal-wrist flap is preferable. (Fig. 15.) However, if the final color of the graft is a vital factor, then a clavicular (Fig. 14) or a cervical tube flap should be considered. The advantages and disadvantages of the clavicular and

cervical flaps have been considered in the section on defects of the upper lip.

When the entire thickness of the tube is

In the great majority of large defects at the labial commissure, it is not possible to reconstruct the angle and adjacent
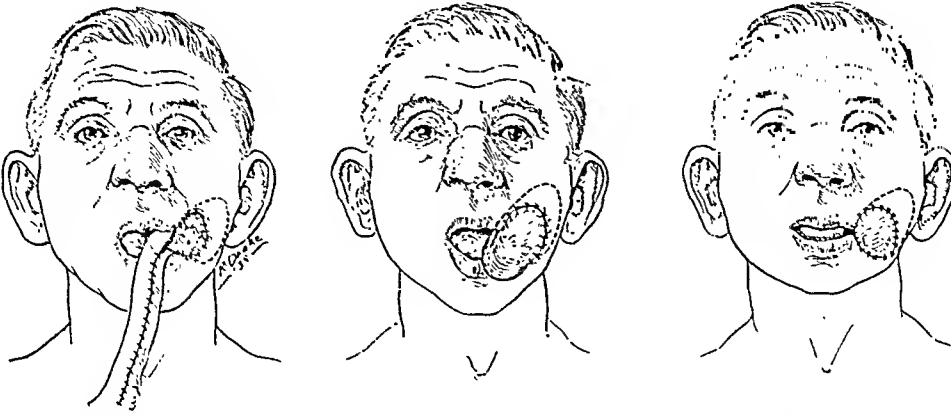
FIG. 20. Closure of a defect at the angle of the mouth by means of a tubed skin flap. In the procedure shown in this illustration, the tube is used both for the lining and for the covering of the reconstructed region. The tube is first sutured around the defect with its skin surface directed toward the interior of the mouth. The tube is then folded on itself and, when sutured around the defect, forms the external surface for the reconstructed part. The excess fat can be removed later. (In this particular case the residual scarring inside the left cheek secondary to the removal of an epithelioma produced complete ankylosis. After excision of this scar tissue the tubed flap was inserted within the mouth as is shown to cover the raw area and correct the ankylosis.) (From New and Figi, in *Surg., Gynec. & Obst.*, 62:182, 1936.)

employed in the reconstruction, no lining is needed because the inner surface of the tube forms the lining. If the end of a tube is used, then it must be lined either by folding or by the use of a full-thickness skin graft. Frequently, in defects below the vermilion border, a flap of skin from the tissues adjacent to the wound can be turned into the defect to form a lining.

DEFECTS INVOLVING THE ANGLE OF THE MOUTH

The most uninvolved method of repairing smaller defects limited to the angle of the mouth is to remove a wedge of tissue above and below the opening; this leaves a diamond-shaped wound which is easily closed. (Fig. 16.) A more extensive loss of labial tissue involving the angle and a portion of the adjoining lower lip frequently may be treated without the aid of a delayed or tubed skin flap; a repair can be effected by turning up a flap of skin into the defect for a lining and bringing the skin edges over this flap to cover the wound. (Fig. 17.)

cheek by adjusting, shifting, or manipulating the surrounding tissues. In such cases, it is essential that skin be conveyed
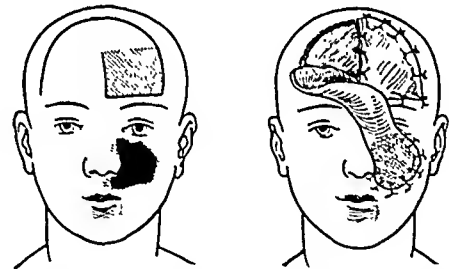
FIG. 21. Closure of a large defect of the upper lip and cheek in women by means of a horseshoe-shaped, delayed, pedicle flap of skin on the forehead. The distal end of the flap is brought down and sutured to the margins of the defect, while the region of the forehead left devoid of skin is covered with a full-thickness skin graft. Finally, the pedicle is severed at the upper margin of the defect and the unused portion is returned to the forehead.

to the defect from a distant source. This can be accomplished by means of a forehead flap with a pedicle in the temporal region or by a tubed clavicular, cervical, chest or abdominal-wrist flap. The circumstances

governing the choice of the ideal flap to use in any given case of a large defect at the labial angle are no different from the factors, already described, which influence the selection of one or another type of skin flap in defects of the upper and lower lips. Yet, we should like to call attention to the three methods in which any one of these flaps may be lined so as to form an internal covering for the reconstructed labial angle and contiguous part of the cheek: (1) If the condition of the adjoining tissues will permit, a flap of skin may be turned into the defect to form a lining. (Fig. 18.) (2) The end of the tube flap can be lined with a full-thickness skin graft. (Fig. 19.) (3) The extremity of the tube may be folded to form a lining. This procedure may be carried out in two ways: (a) folding the end of the flap before it is transferred to the defect; or (b) suturing the end of the tube around the defect with its skin surface directed toward the interior of the oral cavity and subsequently folding the tube back on itself so as to form a covering for the reconstructed part. (Fig. 20.)

A defect involving the cheek and extreme outer portion of the upper lip above the angle of the mouth can be closed quickly and nicely in women and occasionally in men by means of a horseshoe-shaped forehead flap with a pedicle in the supraorbital region on the side of the face opposite the defect. (Fig. 21.)

CONCLUSION

We would like to state that no originality on our part is claimed for the various methods of repair which have been described in this paper. Instead, this article consists of a collection of technical procedures or modifications of such procedures, originated by others and used at The Mayo Clinic in plastic reconstruction of postoperative defects of the lips.

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JAW RECONSTRUCTION

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THE following discussion will be limited to reconstructive problems of the mandible. It is necessary from the outset to realize the status and importance of the mandible in the body economy. Its main function is that of a support for the dental mechanism. Secondly, it has great cosmetic value and supplies the normal contours to the lower half of the face. Finally, because of its close relationship with the tongue and tissues of the hypopharynx, it affects speech and swallowing.

There are many minor deformities of the mandible which are dental in their scope. Irregularities of teeth, loss of teeth, and changes in the alveolar process are some of such minor deformities which will not be discussed here, but which must be mentioned, since they affect mastication and phonation, two primary functions of the mandible.

The three major types of deformities consist of: (1) those in which there is loss of bone with the continuity of the mandible definitely disturbed; (2) those in which there is maldevelopment and retrusion of the mandible; (3) those in which overdevelopment of the mandible such as occurs in prognathism, open bite, etc., is present. Subdivisions to these main topics will be made below.

I. BONE LOSS IN THE MANDIBLE

The main causes of important loss of bone in the mandible are osteomyelitis, trauma—especially gun shot wounds—and surgical intervention for the removal of new growths. The destruction caused by osteomyelitis varies in extent. Unless the final defect leads to definite loss of continuity, it does not create a major problem for the reconstructive surgeon. In radiation necrosis, on the other hand, eventual loss of bone is usually quite extensive. In one of my cases, the necrotic mandible had to be removed entirely.

Loss of continuity of the mandible is accompanied by distortion and poor function to a varying extent. When the continuity of the mandible is disturbed, the muscles of mastication lose their normal coördinated action. As a result their individual actions pull the mandible in various directions. This, combined with cicatrices of the surrounding soft tissues may cause considerable distortion of the remaining bony fragments.

Trauma as a cause of bone loss in the mandible is a direct factor in gunshot wounds; indirectly, it is a factor in producing compound fractures and osteomyelitis.

One of the main causes of loss of mandibular bone is surgical intervention for the treatment of benign or malignant tumors of the jaws. Carcinoma, fibrosarcoma or osteogenic sarcoma are the three main types of malignant disease affecting the mandible. Of the benign growths, adamantinoma and benign giant cell tumors commonly cause important defects in the bone. Deformities from malignant disease are not favorable cases for effective reconstructive surgery, as surgical treatment is primarily concerned with combating the recurrence of disease. In non-malignant tumors, however, one takes greater liberties, as such patients are often young and the chances of recurrence are almost nil if operation is performed radically.

Adamantinoma occurs in the young and as the surgical treatment consists of the removal of a section of mandible, there often results a large defect which frequently involves almost the entire half of the mandible, and occasionally the median section of the mandible. Benign giant cell

tumors of central origin, if extensive, are also treated radically.

In the treatment of mandibular defects

FIG. 1. X-ray showing tumor mass extending from angle of jaw to median line of mandible. (Case 1.)

resulting from loss of bone two procedures are available: (1) the transplantation of bone; or (2) the construction of a prosthetic appliance. Transplantation of bone is the method of choice and it is most satisfactory to the patient. There are times, however, when owing to surgical difficulties or to the patient's unfavorable physical condition and many other factors, it is advisable to use a prosthetic restoration either as a temporary expedient or as a permanent therapeutic measure.

Transplantation of bone is most favorable when the defect is within the body of the mandible. It becomes increasingly difficult as the loss of bone involves the ramus or includes the condyle. This is partly due to difficulties incident to immobilization of the parts following operation.

A. Methods of Bone Grafting. The fundamental principles of bone transplantation are the same in any area of the body. (Mercer.[1]) The particular difficulties encountered in the jaw are compensated for in general by the richness of the blood supply present. The oral cavity is always contaminated and presents a hazard if entered during surgery on the jaw. The

degree of available postoperative immobilization is often limited.

Since the World War, surgical restora-

FIG. 2. X-ray following removal of tumor mass including ·section of mandible—splint in position. The splint consists of a stout arch wire attached to metal bands which were fitted over selected teeth on normal side of the mandible. An adjustable fork was connected to the end of the arch wire which was fastened to the stump of the ramus following operation. The distance was regulated by a threaded nut which held the ramus as far back as was necessary. (Case 1.)

tion of the continuity of the mandible has been brought about by two methods: (1) the massive bone graft, preferably taken from the crest of the ilium; and (2) osteoperiosteal grafting. Both procedures are useful. Ivy and Curtis recommended osteoperiosteal grafts for defects of the mandible 2 cm. or less in extent, and in cases where the external contour of the face showed little or no deficiency.

The writer prefers osteoperiosteal grafts even in larger defects. However, the method of bone grafting adopted is different from that which Delaginière first described. My procedure consists of using osteoperiosteal transplants taken from the tibia about 2 mm. in thickness; where bulk is a factor several pieces are used. My reasons for adopting this method are: (1) this type of graft contains all the elements necessary for osteogenesis; (2) it is sufficiently flexible to use in many cases; (3) the

echnique of removal and insertion is simple; and (4) when used severally they give as sufficient bulk as desired.

Preoperative Preparation of the Patient. In the preparation of the patient, the general physical condition must be carefully evaluated. Any acute or chronic illness definitely increases the surgical hazard. Metabolic diseases and deficiencies must be recognized. Finally the operative area must be free from infection. This point is not always easy to determine. The passage of time since the primary condition or surgery helps to rid the area of infection. A six months' wait may be stated to be the minimum after any suppurative process.

In the occasional case, preliminary surgery may be more extensive and painstaking than the final transplantation of bone. This will be true when the soft parts need reconstructing in order to prepare a bed for the reception of the transplant. The use of delayed flaps and various plastic procedures may be required.

Case I. S. L., age 12. Two years before this boy's first admission to the Massachusetts General Hospital, August 1, 1925, his parents

Fig. 3. *X*-ray of jaw three years after osteo-periosteal transplant. (Case I.)

noticed a swelling over the right cheek which was caused by a tumor mass of the lower jaw. This increased in size during the next two to three months. He was operated upon at a local hospital, and had an uneventful convalescence. For the next two to three months the mass was

Fig. 4. *X*-ray showing defect of bone, extending from the neck of the condyle to the bicuspid region. (Case II.)
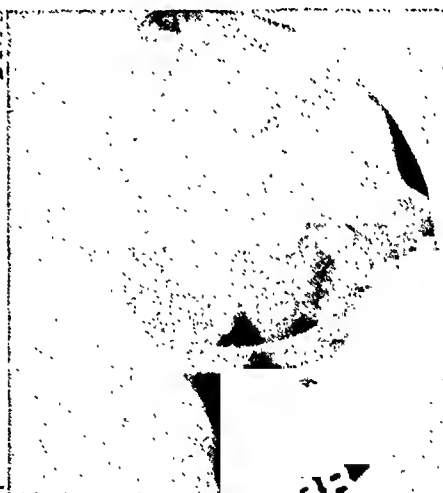
Fig. 5. *X*-ray showing transplant, extending from the neck of the condyle to the bicuspid region, six months after operation. (Case II.)

Sometimes the correction of alignment may be the primary purpose of one's preliminary operation. Finally the operator must carefully prepare his splints for postoperative immobilization after transplantation. The presence of teeth to act as abutments for splint attachments are so important that their absence may cause the surgeon considerable handicap.

smaller in size; it then increased to a size larger than it had previously attained.

Examination on admission showed a hard swelling of the right side of the face involving the mandible. The tumor mass was smooth in contour and firmly attached to the bone. It extended from the angle of the jaw almost to the median line. *X*-ray showed a cyst-like mass

occupying the greater part of the body of the mandible. (Fig. 1.) Its outline was sharply lobulated and it contained coarse trabeculae.
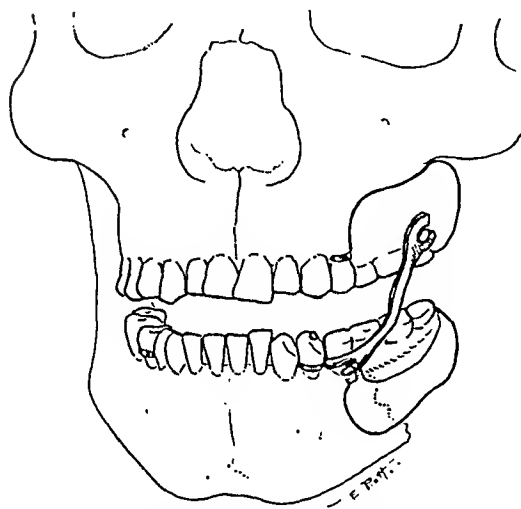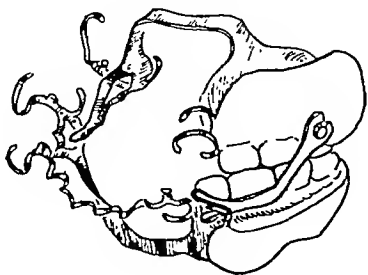
FIG. 6. This appliance was made for a patient operated upon for adamantinoma of the left mandible. The missing bone extended from the left bicuspid region backward. The appliance consisted of two dental plates connected by a bar at upper end of which was a hinged joint. The fork at lower end rests on a small bar incorporated in the lower plate. As the mouth opens there is no disturbance of the lateral motions of the jaw. When the teeth are in contact the bar forces the lower jaw into normal position.

The diagnosis was sarcoma or giant cell tumor. Operative treatment was advised.

Previous to operation models were taken and a splint constructed. The operation was performed under avertin and intranasal ether. A semicircular incision about 15 cm. long was made, extending upward toward the lip. The right side of the body of the mandible was excised with a saw and bone-cutting forceps. The wound of the floor of the mouth was closed, and the skin closed over a pad and rubber drain. The previously prepared splint was adjusted. It encircled several of the teeth on the

left and engaged by an adjustable fork, the stump of the ascending ramus on the right side. (Fig. 2.) The patient made an uneventful
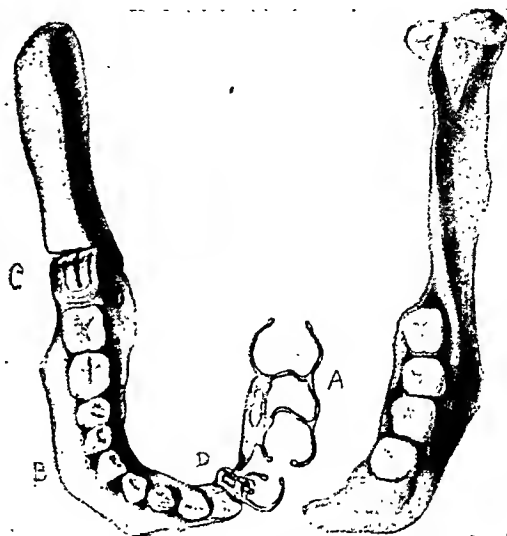
FIG. 7. Permanent prosthesis, following extensive resection of the mandible. As seen in the diagram, the appliance consists of two main sections: A, series of crib clasps fitted over selected teeth on left side; B, a vulcanite plate more or less shaped to the contour of the mandibular bone designed to replace the missing segment. There are two hinged joints, one at the angle of the artificial ramus, C, the other at the junction of the clasps and vulcanite plate, D. The purpose of these joints is to give more flexibility to the apparatus and to prevent undue strain on the teeth carrying the clasps.

recovery and was discharged from the hospital on August 30, with the appliance in position.

At his second admission, January 31, 1933, the boy was in good physical condition, and there was no evidence of recurrence of the tumor. It was decided to operate and transplant an osteoperiosteal graft.

An incision was made along the old scar and the mandibular stumps were freely exposed. Two pieces of osteo-periosteal graft, about four inches long and one-half inch wide, were removed from the left tibia and transferred to fill the gap in the mandible. The transplants were held in position by buried sutures. The jaws were then immobilized by wiring.

The patient made an uneventful recovery and was discharged from the hospital on February 8, 1933. (Fig. 3, final x-ray.)

Remarks. This case illustrates the importance of maintaining the two parts of the mandible in their normal position immediately

after the sectioning is done. This patient was able to tolerate the intraoral dental splint one end of which was fastened to the lower end of

section of bone was obtained. A similar smaller shaving was also taken. The large piece was slipped in from below upwards to articulate

Fig. 8. Case III, showing symmetrical bilateral retrusion of the mandible. (From Kazanjian, in *Internat. J. Orthodontia*, 22:259, 1936.)

the ramus, from August 15, 1925 until long after the bone graft was inserted.

CASE II. N. A., 11 years old. This girl had a non-malignant tumor removed from the lower jaw on August 3, 1937. It had been necessary to excise part of the mandible extending from the neck of the right condyle to the second bicuspid region. (Fig. 4.) In order to maintain the remaining part of the mandible and the occlusion of the teeth in their normal position the following simple method was used: brass wires, 20 gauge, were passed around the upper and lower premolars and their twisted short ends were bent to form hooks. Elastic bands were extended from the upper to the lower hook in such a direction as to prevent the mandible from displacing backward.

From then until the patient was ready for the next operation for bone grafting September 3, 1937, the elastic bands were used as an effective and easily adjustable method of retention. Repeated x-ray studies were made during the follow-up of this patient but new bone formation was very limited. On September 23, 1937, it was decided to transplant bone.

The patient was operated on under ether anesthesia on November 1. An incision was made over the right temporomandibular joint and carried down to the capsule of the joint. By blunt dissection the ramus of the jaw was explored. A second incision approximately at the angle of the jaw was then made and the dissection carried upward until the two met. From the tibial cortex a 6 × 2 cm. rectangular

with the temporomandibular region. The patient was returned to the ward in good condition after both jaws were wired together in proper occlusion.

Immobilization of the jaws was maintained for a long time. On January 6, 1938, the wires were removed. On February 10, good union, good occlusion, and good excursive movement of the mandible were present. (Fig. 5.)

Remarks. In pathologic conditions necessitating the removal of the ascending ramus, I would suggest that surgeons spare the head and neck of the condyle if these are not invaded by disease. My reason for this suggestion is that future reconstruction by bone grafting is more favorable if the head of the condyle is present.

B. Prosthetic Restorations. Since the main purpose of our surgery in these cases is the reëstablishment of function in the mandible, it is necessary to discuss briefly prosthetic considerations. One point often not recognized is that a good prosthetic appliance will make possible and establish function in the remaining part of the mandible. It can be commonly observed that destruction of one condyle, or even part of the ramus, does not necessarily indicate loss of functional power. Neither does it show any marked degree of external deformity, provided the normal action of the jaw is not handicapped by adhesions

and scars. The situation is reversed, how-ever, when the missing bone involves, in addition to the ramus, any part of the body

FIG. 9. Diagram showing L-shaped sectioning of the mandible. The lower arm of the L should be long enough to have contact with the posterior portion of the mandible when the anterior part is advanced.

of the mandible anterior to the attach-ments of the masseter muscles.

Artificial restoration of the mandible has definite problems of its own. Unlike the maxilla, the mandible depends on active movements for its function. The primary object is to preserve the functioning of the remaining part and to a lesser extent re-store the face to its normal contour. The degree of functional power is dependent upon the size and anatomic position of the existing bone, and upon the presence or absence of teeth. The remaining part of the mandible is usually distorted laterally and backward, disturbing the occlusion and the normal functioning of the teeth. The temporomandibular joint is completely obliterated and the unaffected side of the face is more or less flat.

The first step is to correct the distortion of the existing segment of the mandible so

that the remaining teeth will be in normal position. In favorable cases this may require only a certain amount of mechani-
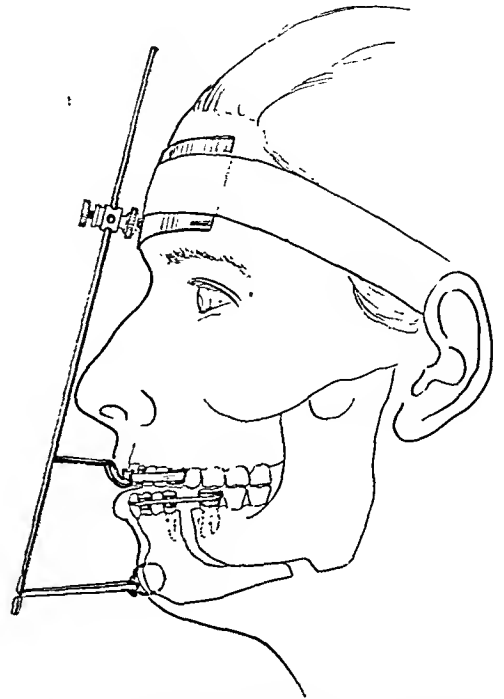
FIG. 10. Diagram showing method of pulling the chin forward after sectioning of the bone. The median bar is anchored to the forehead and the upper teeth. A brass wire is passed through a hole at the symphysis and comes through the skin so as to form a loop in front of the chin. An elastic band extends from the wire loop to the bar in front.

cal manipulation with orthodontic appli-ances; in others, complicated by the presence of cicatricial tissue, it may be necessary to eliminate such handicaps by surgery as a preliminary step to prosthetic restoration.

Two types of appliances may be used quite successfully. First, a retention appli-ance, its main function being not so much to correct facial contour as to facilitate the functioning of the remaining mandibular segment. Such an appliance may extend from the last tooth of the anterior segment on the defective side, backward and up-ward toward the maxillary third molars, where a pseudo-temporomandibular joint is made in the form of either a groove or a ball-and-socket joint. (Fig. 6.) The funda-mental purpose of this appliance would be

to prevent the backward and inward swing of the remaining segment of the mandible.

The second type may be called the

FIG. 11. Models of patient (Case III) showing relation of lower teeth to the upper prior to operation. (From Kazanjian, in *Internat. J. Orthodontia*, 22:259, 1936.)

FIG. 12. Case III, after operation in which two pieces of rib cartilage were inserted in front of the symphysis. (From Kazanjian, in *Internat. J. Orthodontia*, 22:259, 1936.)

artificial jaw type of appliance and is useful only in rare cases. With this appliance deformity and disability are avoided from the beginning. The method consists of introducing into the wound an artificial restoration, the approximate size and shape of the bone removed, extending from the articular eminence to the stump of the remaining mandible. (Fig. 7.) The restoration stays in position until the wound has healed, but not infrequently skin grafting within the buccal cavity becomes necessary to avoid contractures. The final prosthesis is made with attachments to be fastened over the remaining teeth. This method was first advocated by Claude Martin, and has been elaborated and perfected by our European colleagues, including Schroeder, Ernst, Pichler and others.

During the World War it was conclusively demonstrated that for successful plastics of the lip, cheek, and chin, when the destruction involved the maxillary and mandibular bone, it was necessary for the prosthetic appliance to be constructed prior to the operation for repair of the part.[2,3,4] This is also true in civilian life, with patients who undergo operative treatment for the removal of various tumors. Thus we see the close relationship of surgery and prosthesis; and on this basis, we may justly consider surgical prosthesis as a branch of restorative surgery.

II. SYMMETRICAL BILATERAL RETRUSION OF THE MANDIBLE

In patients with symmetrical bilateral retrusion, the mandible is uniformly small and it is markedly retracted in relation to the upper jaw. (Fig. 8.) Not infrequently

the symphysis menti is not developed normally, thus exaggerating the deformity of the lower half of the face. Examination of

III (K. C.) gave a history of severe birth injury, but he also had bilateral congenital microtia, so it is not certain whether or not

FIG. 13. Final photographs of patient (Case III) following advancement of the lower jaw.

FIG. 14. Case IV, showing asymmetrical retrusion of the mandible. Note the shortness of the mandible on the right side, which is the main cause of the deformity.

the teeth in these cases shows a considerable horizontal space between the upper and lower anterior teeth.

This deformity may be congenital in origin, but most frequently is due to arrested growth of the mandible because of (1) birth injury, (2) trauma, (3) infection involving both sides of the mandible, or (4) bilateral ankylosis at an early age.

It is difficult causally to relate birth injury to the decreased growth of the mandible and unless the birth injury caused an overlapping fracture or was followed by osteomyelitis there is no reason to suppose that mere fracturing of the infant's jaw should affect the mandibular growth. Case

this and similar cases are congenital or traumatic (birth injury) in origin.

Retrusion of the mandible may result from maltreated bilateral fracture of the necks of the condyles, where the head of the condyle is pushed out of its socket, the effect being retraction of the entire mandible, backward, with open bite.

In bilateral ankylosis in childhood, generally there is a symmetrical lack of growth, but the predisposing cause is not the lack of functioning of the jaw but the original trauma or infection which disturbed the growth centers of the jaw and led to underdevelopment of the mandible. This point is well illustrated in cases where

there is asymmetrical retrusion of the jaw in unilateral ankylosis. Here the function of the jaw is lacking, but while the affected

position for such reasons. Purely cosmetic surgery is always possible by building up the chin with cartilage grafts in front of
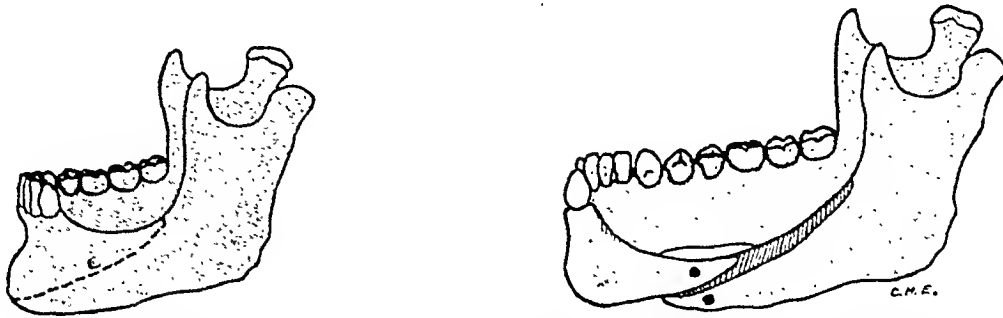
FIG. 15. Diagram showing diagonal cut through the body of the mandible for the lengthening of the short side of the mandible. This method is useful when the affected side is edentulous. (*The Apollonian*, Jan. 1937.)

FIG. 16. Final photographs of patient (Case IV). In addition to lengthening the short side of the mandible two pieces of bone transplant were added to the chin and to the left side.

side is considerably shortened, the non-affected side of the mandible grows to almost normal size.

Treatment. Marked deformities of this type in young patients should be corrected surgically with the hope of improving the occlusion of the teeth and relieving the patient of a marked deformity.

Preoperative measures should include a careful study of the existing relations of the upper and lower teeth, and of the possibility for improving the occlusion after the operation. One has to consider the possibilities of future orthodontic and other dental treatment for increasing masticatory power of the teeth. It is sometimes better to limit the advancement of the mandible to less than the ideal esthetic

and at the sides of the symphysis. As the operation itself consists of advancing the mandible by cutting through it on each side, it is important to make provisions for immobilization of the mandible following the operation. Thus adequate dental splints become a necessary prerequisite.

Operation for Retrusion. The most important surgical procedures are: (1) advancing the mandible forward; (2) correcting further deformity by dental treatment; and (3) transplanting bone or cartilage along the median or lateral surfaces of the mandible as necessary.

Various methods are advocated for the advancement of the mandible. These consist of: (1) cutting through the ascending ramus; (2) approaching through the body

of the mandible; and recently, (3) transplanting a piece of cartilage posterior to the head of the condyle. (See Babcock.[5]) Of

saline is flushed into the area and continually aspirated with suction, thus keeping the field clear of blood.
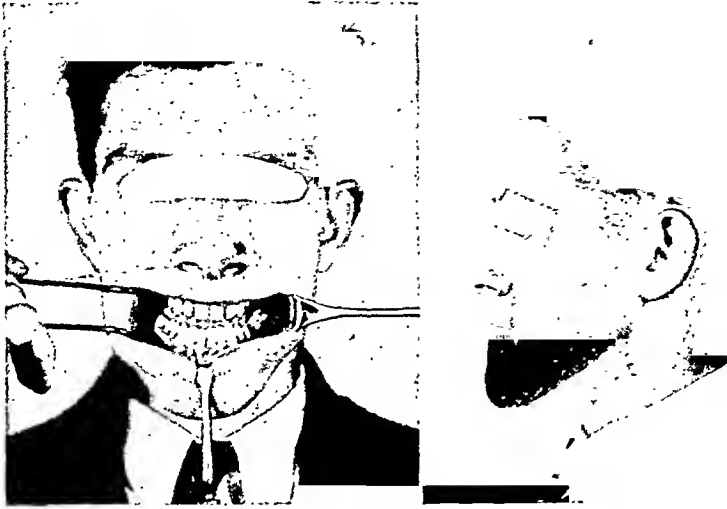
Fig. 17. Preoperative photographs in Case v showing mandibular prognathism.

these several methods, the simplest and most logical procedure is to advance the body of the mandible. (Fig. 9.) The operative approach is through the buccal cavity. Local anesthesia is preferable in adults, but children are operated on under general anesthesia.

1. The second premolar tooth is sacrificed and a U-shaped incision is made through the buccal mucous membrane. The lateral surface of the mandible is exposed from the mental to the retromolar region.

2. The mental foramen is located and exposed.

3. With a small surgical burr (No. 6) holes are made through the mandible, at first vertically, from the socket of the extracted premolar to some distances below the mental foramen, in order to insure against damaging the roots of the teeth. At this point the holes are made in a horizontal direction, as far as the operator thinks necessary to insure bony contact of the two fragments after advancement of the mandible. The bone between the holes is then cut through with surgical burrs.

After this procedure, sharp axe-shaped chisels may be used to fracture the bone completely. During this cutting process

4. The same procedure is applied on the other side, and the anterior segment of the mandible is brought forward and immobilized in its new position. If the patient is operated upon under general anesthesia, wiring of the upper and lower jaws is postponed until the patient is free from post-
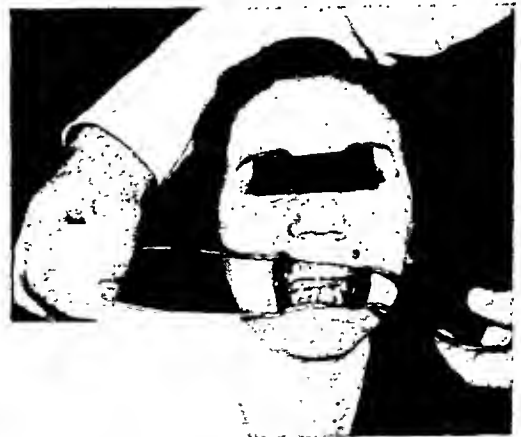
Fig. 18. "Open-bite." The contact of upper and lower teeth is limited to the last molars.

operative vomiting. However, properly made dental splints will afford enough fixation of the fragments without intermaxillary wiring.

5. In order to get the maximum effect from this operation it is necessary to use external pull on the symphysis to obtain a

more exact and controllable advancement of the chin. This is effected by passing a wire suture directly through the symphysis

confusing. The parents attribute his condition to a birth injury, but the deformity of the ears is definitely congenital, and there is every
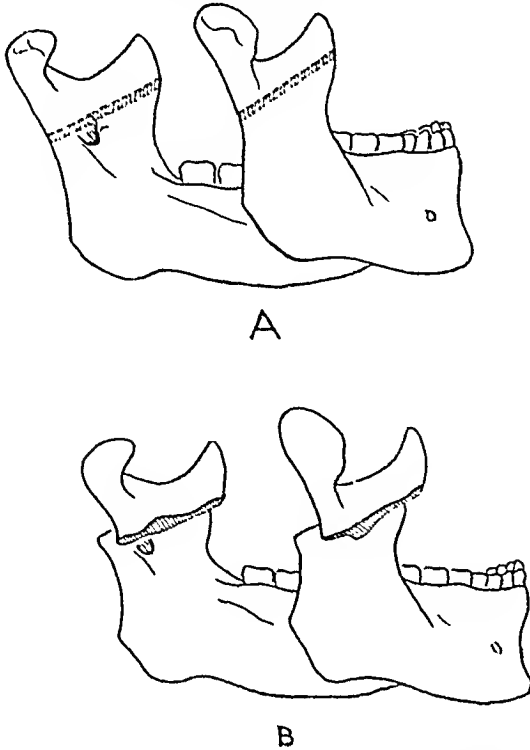
Fig. 19. Diagram showing the correct location and direction of the cut through the ramus. When the mandible is pushed back there invariably is an overlapping of the two sections.
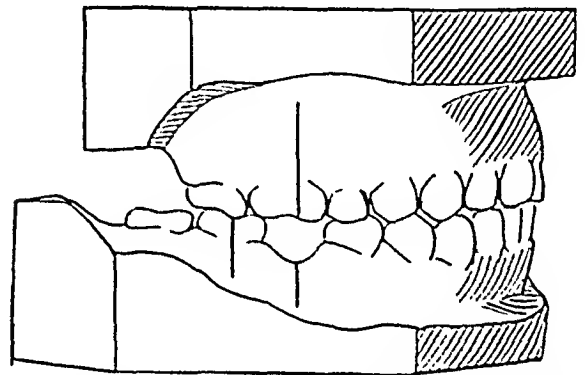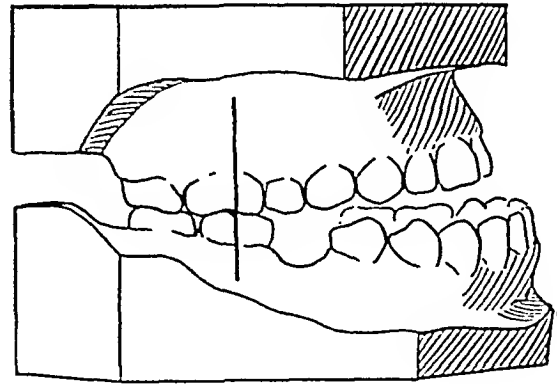
Fig. 20. Diagram showing the method of measuring the size of section of bone to be removed. (From Kazanjian, in *Internat. J. Orthodontia*, 22: 259, 1936.)

and attaching to this an elastic band leading to a bridging arch of wire coming down over the midline of the face from the forehead. The wire arch or bridge rests on a forehead frame imbedded in dental composition and also on a band on the upper incisors. An extension over the chin affords a point of attachment for the elastic band. (Fig. 10.) A stab wound is made leading under the jaw line externally and a rubber dam drain is placed in that site (removable externally). The intraoral incision wound is then sutured.

6. If the described surgical procedure is not sufficient to gain for the patient the necessary prominence of the chin, it is possible some months later to transplant a section of rib cartilage or preferably bone, over the anterior surface of the symphysis.

CASE III. K. C. This boy (Fig. 8), first seen when fourteen years old, had congenital microtia, right and left, and a deformity of the chin. The patient's early history is rather

reason to believe the underdevelopment of the chin is also congenital. Examination of the teeth was interesting as the patient had retroclusion with excessive fullness of the maxillary alveolar arch and a separation of the anterior teeth. (Fig. 11.) After consultation with the Orthodontic Department, it was decided not to disturb the existing occlusion of the molars and bicuspids, but to remove a maxillary bicuspid on each side and push the maxillary anterior teeth back with orthodontic appliances. This was considered advisable because of the excessive fullness of the maxillary alveolar arch. While the orthodontic treatment was being carried on, the patient was admitted to the Massachusetts Eye and Ear Infirmary for the surgical treatment of the microtia and the deformity of the chin. I shall omit here the details of treatment of the microtia. Two operations were performed for transplantation of rib cartilage to the chin, with rather gratifying results. (Fig. 12.)

Unfortunately, regulation of the teeth met with difficulties and after studying the deformity more carefully it was apparent that more frequently than bilateral symmetrical retrusion of the mandible. It has the same etiologic factors except that close examina-
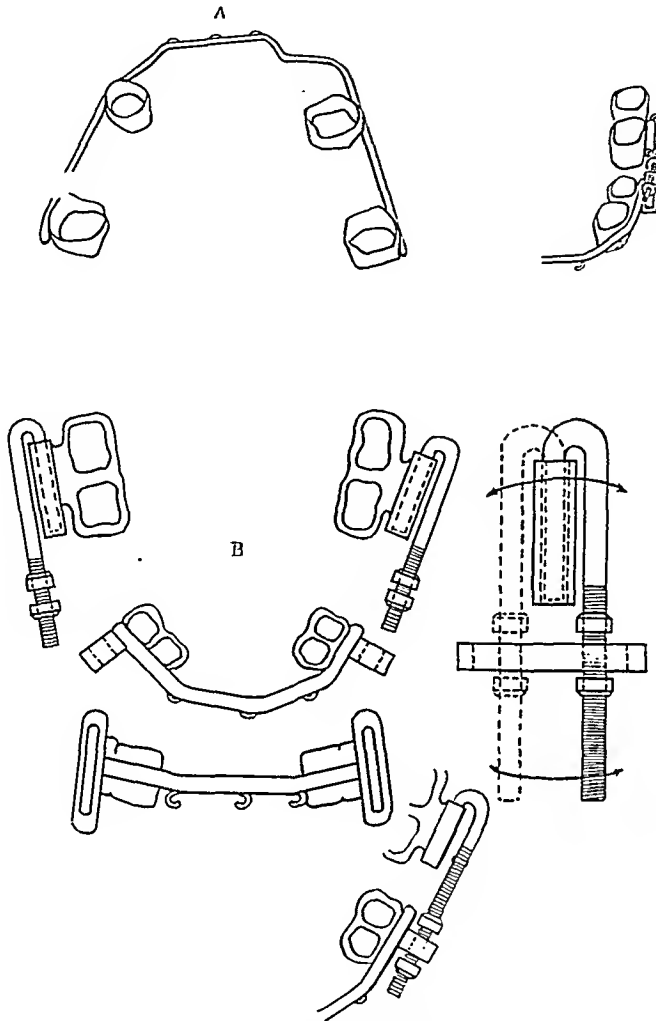
FIG. 21. Diagram of splint. (See text.) (From Kazanjian, in *Internat. J. Orthodontia*, 22:259, 1936.)

mere regulating of the teeth was not a satisfactory solution of the deformity. While the patient was at the Eye and Ear Infirmary for operation on microtia, it was considered advisable to do an osteoplastic operation and advance the jaw forward.

The operation was performed Oct. 1, 1938, under novocaine anesthesia along the lines described in the text. The improvement of occlusion of the teeth and of the facial contour was immediate. (Fig. 13.)

ASYMMETRICAL RETRUSION OF THE MANDIBLE

Asymmetrical retrusion of the mandible is a distinct type of deformity and is seen tion will show arrested development of one side of the mandible only. Thus the unaffected side is longer when measured from the center of the chin to the tragus of the ear—sometimes as much as 2 or 3 cm. The picture is quite typical. (Fig. 14.) The chin is markedly retracted and deviated to the short side of the mandible. The face is flattened on the unaffected side and full on the affected side, a point which may lead to a mistaken diagnosis. The deformity varies directly with the earliness of the onset.

Examination of the mouth often shows the posterior teeth on the affected side to be

missing. The occlusion of the teeth may be disturbed considerably. The normal vertical axis of the teeth is changed to the

obtained. The wire sutures are removed in due time, and they rarely cause any disturbance.

FIG. 22. Case v, postoperative photographs.

opposite direction, so much so, that the lower teeth instead of slanting buccally are bent medially. This process takes place gradually as the child grows.

Operative Treatment. Surgical treatment in such cases consists primarily of elongating the short side of the mandible. However, here again one must consider the effect of correction on the dental mechanism. Therefore, the same study and pre-operative measures are as essential as in the cases of bilateral symmetrical deformities.

The operative method which I have adopted, is to make a diagonal or L-shaped incision through the short side of the mandible with a surgical burr, and to elongate it as much as is practical. (Figs. 9 and 15.) Often the occlusion of the posterior teeth is considerably disturbed but this is later corrected by orthodontic measures.

The immobilization of the resulting fracture is effected by suitable dental splints if sufficient teeth exist on each side of the fragment. If teeth are not available, holes are made in the extreme ends of the disconnected bone with a surgical burr. A stainless steel wire (No. 20 gauge) may be used to connect the two ends together. The twisted wire is allowed to protrude through the mucous membrane. By this procedure as much as an inch of lengthening may be

If additional improvement of the facial contour is desired, transplantation of bone or cartilage is resorted to at the symphysis or even at the side of the mandible.

CASE IV. K. R. I first saw this patient November 18, 1927. Her parents stated that she had had a severe infection that broke out on her face, hands and thighs, eight days after birth (cesarean). Since then the jaw had grown progressively deformed. (Fig. 14.)

The patient was not seen again until November 24, 1936. She had been receiving orthodontic treatment, but it had not been of much benefit. The lower right second bicuspid was extracted and splints were constructed to be used following operation for lengthening the jaw.

On September 7, 1937, an operation was performed under ether anesthesia. An incision was made over the alveolar crest of the right mandible, rather far back. The mucous membrane was incised and stripped back, exposing the outer aspect of about one-third of the body of the mandible. With the bone drill an L-shaped section was made through the mandible, the short vertical arm in the molar region and the long horizontal leg of the L running slightly downward until it passed through the inferior border of the mandible. (Fig. 9.) A drill hole was made in the tip of the anterior section of bone near the inferior margin and a wire suture was passed through this and brought out to the surface of the chin. A stab wound was made to the outside, under the

border of the mandible, and a rubber dam drain brought through and sutured to the chin. Previously prepared dental splints were at-

accomplished in the way of improving the occlusion.)

When the patient was seen on December 20,
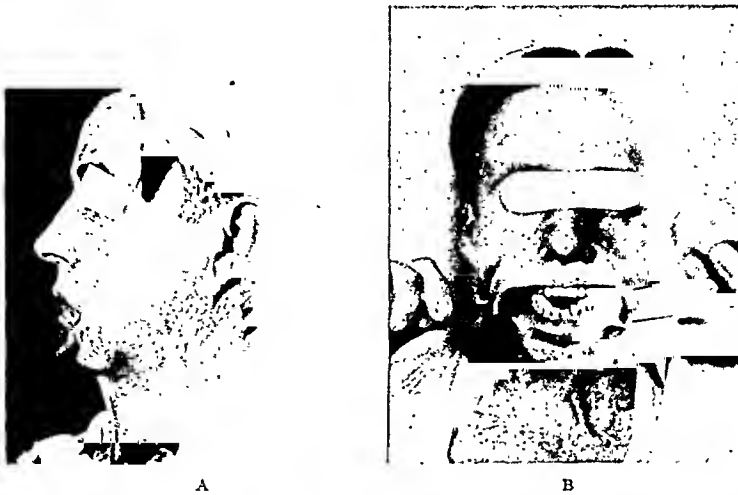
FIG. 23. Case VI, preoperative photographs.

FIG. 24. Case VI, postoperative photographs.

tached to the teeth on either side of the section and a bar was fixed which spread the mandibular fragments apart to the desired extent and fixed them in position. Pressure dressing was applied to the outside of the face.

Immediately following the operation a special splint was devised to effect a direct pull on the anterior fragment at the symphysis. (Fig. 10.) This splint was supported at the forehead and over the upper teeth, and extended in front of the chin. It pulled on the symphysis by the force of rubber bands extending from the metal bar in front of the chin to the wire loop from the symphysis. It was maintained in position for about ten days. (Following this the patient was seen at my office, and a certain amount of orthodontic work was

1937, complete consolidation of the jaw was found, with marked improvement of the facial outline. She was discharged until the following summer.

On July 21, 1938, a second operation was performed, the purpose of which was to improve the contour of the chin and left side of the jaw. Under ether anesthesia, an incision was made along the crest of the right tibia. Two good sized pieces of bone were obtained from the tibial crest. These were each roughly 3 × 5 cm. in their dimensions. An incision about 2½ inches long was made under the chin line. Through this the skin was undermined freely down the neck and a deeper dissection was also carried out, releasing a fat flap which lay underneath the chin. This was

removed, piecemeal, reducing the contour of the under chin. With the periosteal elevator, largely by blunt dissection, the periosteum of

III. PROGNATHISM

Protrusion of the mandible and mandibular curvature causing so-called "open-

Fig. 25. Case VII, preoperative photographs.

Fig. 26. Case VII, postoperative photographs.

the chin proper and to the left of the chin was exposed and elevated. Both the fragments of bone obtained from the shin were planted, one directly over the mental protuberance and the other laterally. These pieces contributed to the yielding of a more prominent chin, and filled out the depression at the left of the chin. A small rubber dam drain was applied down the neck.

Following this operation the contour of the chin was quite satisfactory. (Fig. 16.)

Since the first operation the patient has been under the care of an orthodontist (Dr. Blumenthal) who has accomplished considerable improvement of occlusion of the teeth.

Remarks. In an operation of this type one is obliged to disturb the occlusion of the existing teeth more or less, but in young patients judicial orthodontic treatment combined with various types of dental restorations have given satisfactory results.

bite," form definite types of deformity. In prognathism there is an overgrowth of the mandible in relation to the upper jaw. (Fig. 17.) In "open-bite" the lower jaw may or may not be overdeveloped, but owing to its peculiar configuration there exists an abnormal space between the upper and lower teeth. (Fig. 18.)

Mandibular prognathism may be due to hereditary causes, to trauma, or to disease. It is usually accentuated by mechanical factors such as pressure of the lip muscles and tongue or the teeth themselves. In supporting the inheritance factor as an etiologic cause, we see these conditions prevalent in different members of the same family, and it seems to exist more frequently in some races than in others. Many patients, of course, report for treatment with the family history perfectly negative.

Blair and Ivy believe that atavism may be the primary factor in such cases. Trauma and disease are responsible for certain types of prognathism and "open-bite." These occur often in children suffering from severe contractures of the neck from old burns. Patients with extensive hemangioma involving the lower half of the face and cheek and tongue often show marked prognathism. This may be due either to abnormal blood supply to the part or to the excessive size of the tongue or to a combination of the two factors.

Malunion following fractures of the jaw may lead to destruction of the normal occlusion of the teeth and "open-bite." Acromegaly is a well known cause, but these cases by themselves do not present problems for reconstructive surgery.

In most cases of mandibular prognathism there is a corresponding underdevelopment of the maxilla which in turn emphasizes the deformity. The upper and lower teeth often have poor contact and it is possible that the abnormal occlusion and plane of the individual teeth gradually displace the lower jaw and accentuate the deformity.

Treatment. A mild degree of protuberance of the mandible is suceptible to orthodontic treatment if the condition is detected early. However, extensive cases are definitely surgical problems.

One of the great teachers of orthodontia (Angle) first advocated a surgical approach in this type of case in 1898. Since then operations for shortening the mandible have been performed with increasing frequency. A number of operative procedures have been advanced but only two types deserve our attention. One method first employed by Blair[6] consists of removing a section of bone from each side of the body of the mandible; the anterior segment is then pushed back into the new position and immobilized. The second method, advanced by Babcock[7] in 1910, was to cut through the rami above the level of the mandibular canals and to push the mandible back to a desirable position and immobilize it.

The relative merits of these two operative procedures depend first on the type of deformity; second, on the condition of the lower teeth; third, on the relative positions of the dental arches; and finally, fourth, on the facilities for postoperative immobilization of the mandible. My experience with these cases leads me to make the following observations: cross sectioning of the ramus is a simpler operative procedure than the approach through the body of the jaw. Similarly, healing processes seem to be more uneventful when the oral cavity is not penetrated. I have had two cases in which chronic suppuration persisted for a long time when operation through the body of the mandible was performed. In fact, in one case owing to ineffective methods of immobilization, nonunion took place which demanded correction later by transplantation of bone. However, I have found certain drawbacks in making a cross section through the ramus. Three cases operated through the ramus tended gradually to show "open-bite." The first, however, a young man of 25, made an uneventful recovery finally with excellent functional and cosmetic results. Two other patients who had protrusion as well as "open-bite" were successfully operated on but in spite of all efforts could not be prevented from gradually redeveloping opening of the bite. These observations lead me to think that in such operations the upward pull of the masseter and internal pterygoid muscles must be respected. Therefore, in cases with open-bite with unfavorable means of immobilization, and with underdevelopment of the maxilla, causing interlocking of the upper and lower teeth, operation through the body of the mandible is to be preferred.

In general there are two types of operative approach for cross sectioning the ramus (Fig. 19): (1) the closed method, and (2) the open method.

The closed method consists of passing a Gigli saw with a directing instrument along the inner surface of the ramus above the lingula, through two small openings in

front of the ear and below the zygoma and cutting the bone with the saw.

In the open method the operative approach is through an incision about 1½ inches long at the posterior border of the angle of the mandible. The anterior surface of the ascending ramus is exposed and cutting is performed by a surgical burr under direct vision. My preference is for the second method as a safer procedure. The external scar is invariably inconspicuous. (See Case Report IV.)

Operating through the body of the mandible is the most direct method of sectioning the mandible. Incisions are made on the inner and outer gingival borders of the mandible in the first molar region. The periosteum is separated from the bone, and an external incision is made to connect with the inner incision and provide a good exposure of the bone. With the Gigli saw a measured section of bone is removed. The same procedure is then carried out on the opposite side. (Fig. 20.)

Study models are essential when operating through the body of the mandible to determine the ideal location for removing a section and to determine the width of mandible that it is necessary to resect. They also help to decide which teeth should be extracted. The extent of resection needed is usually quite different in the opposite sides of the jaw. (Fig. 21.) Splints for immediate postoperative use are constructed before the operation. These are made in an adjustable form since absolutely accurate resection is difficult to attain.

The splints in the diagram (Fig. 21) are (A) a retention splint fastened to the maxillary teeth and (B) a mandibular splint in three sections. Bands are fitted over the posterior teeth on each side of the mandible and a horizontal tube is soldered to the buccal surfaces of these bands. (See B.) The anterior section of the mandibular splint is made with bands and a stout wire. A vertical slot is soldered at each extremity of this splint. (See B.) The three splints are converted into a single splint after the jaw resection by two hooked wires. The hooked

end of each wire fits into the horizontal round tube and the anterior end of the wire is threaded so that it can be fixed in position, after coming through the vertical slot. (See B.) The amount of thread and the vertical slot allow any necessary adjustments. Intermaxillary elastics are used to fix the jaws together postoperatively, in addition to this mandibular splinting.

Besides the above types of deformity there are many others that are hard to put under a definite classification. Congenital absence of the ramus is a rare deformity of which I have seen four cases, three of them being under treatment.

The effect of contracted scars on the neck and chin upon growing bone is quite marked and causes deformities which are not uniform in character. Figure 23 shows, for instance, a marked forward bending of the alveolar process with definite undergrowth of symphysis menti. In this case the operative procedure in addition to correction of the defects of the soft tissues was to cut through the alveolar process below the apices of the roots of the teeth and to put it back in a new position.

CASE V.   L. S., male, aged 20. This patient (Fig. 17) was first seen July 19, 1937. He had an extreme prognathism of the lower jaw. Arrangements were made with his dentist to make bands for the teeth which would be used as postoperative splints. It was decided in this case to operate through both ascending rami.

The operation was performed December 14, 1937, under local anesthesia. An incision was made just above the lobe of the right ear down along the jaw line for about 1½ inches. Through this wound and by blunt dissection it was possible to expose the lower pole of the parotid gland and the masseter muscle. The deepest portion of the masseter muscle was split and a fair exposure of the mandible was obtained. The ascending ramus of the mandible was visualized up as far as the sigmoid notch. The exposure of the ramus was subperiosteal. The mandible was then cut by repeated drill holes with the surgical burr about 1 or 1.5 cm. below the sigmoid notch. When this fracture was complete, the identical operation was carried out on the opposite side. The direction of the cut was obliquely downward and back-

ward above the point of entrance of the mandibular nerve and vessels into the mandibular canal. Both wounds were then packed with gauze, and then splinting and wiring of the mouth and jaws were carried out in order to set the teeth in their new occlusal relationship. It was possible to reduce the prognathism of the jaw about 1 cm. and to attain a correct occlusion. The teeth were secured in this position by intermaxillary wiring. Sterile gowns and gloves were readopted and each of the face wounds was then resutured in layers, a rubber dam drain in each case leading down to the fracture site. It was detected before closure of the wounds that in addition to the lower fragment of the mandible being pushed back there was an overlapping laterally of the mandible, the lower part carrying over onto the left side. The lower fragment on the right side was deeper to the condylar fragment and was thrust up and to a certain extent medially, and overriding it. (Fig. 19B.) Pressure dressing was applied in the usual manner.

The patient was discharged from the hospital on December 30, 1937. Two postoperative difficulties were encountered in this case. First, it became apparent that a good deal of pull had developed on the incisors. Both jaws had been wired together postoperatively and apparently some sort of fulcrum action and muscle pull had caused this condition. A good deal of tension developed in the incisor area, temporarily loosening the upper middle incisors. The second difficulty was that it took the patient several weeks after the mandible was liberated, before he could open his mouth normally wide. The final result was good. (Fig. 22.)

CASE VI. W. F. a contracture of the neck from the age of 6 following extensive burns. Figure 23 shows the extent of soft tissue contraction of the neck, chin and lower lip, also the marked forward displacement and bending of the lower alveolar process carrying the anterior teeth.

Operation was performed for the correction of the external deformity by utilizing delayed flaps from the back of the neck and the transplantation of a free skin graft. The last operation was performed on November 29, 1937, under novocaine anesthesia. The canine tooth on either side of the lower jaw was extracted and the mucosa cut down vertically on either aspect of the mandible. Submucously a tunnel was made from vertical incision to vertical incision across the bony surface of the symphysis below the level of the apices of the incisors. With a small stiff saw it was then possible to saw through most of the mandible and with the chisel the resection was completed, leaving a rectangular piece of symphysial mandible free, except for the mucous membrane attached to it on either side. This fragment was bent into a more nearly normal position and seemed to fit its new site fairly accurately. It was wired in this new alveolar position. Hemorrhage was under control and an external bandage was used about the chin and head to mobilize the jaw.

The patient was discharged from the hospital December 8, 1937, with a completely satisfactory result. (Fig. 24.)

CASE VII. S. F. I first saw this patient, a white woman, age 20, in 1936. She had marked prognathism of the lower jaw with very poor occlusion of the teeth. (Fig. 25.) The maxilla seemed to be contracted. The contact of the upper and lower teeth was limited to the last molar region. She had already lost the first molars and second bicuspids on each side of the lower jaw. Splints were prepared at the Harvard Dental Clinic similar to the type in Figure 21. The patient was operated on at the Massachusetts Eye and Ear Infirmary February 20, 1937.

Under avertin and ether anesthesia, an incision was made along the superior margin of the gum line of the lower jaw from the bicuspid to the second molar tooth. This was carried down to the bone. The periosteum and mucous membrane were dissected free from the lateral surface of the mandible. An external incision about 2 mm. long was made along the jaw line of the mandible. A section of mandible 8 mm. wide was removed with the Gigli saw. The fragments of the lower jaw were then fixed by the use of wires which were bound onto the dental appliances previously prepared. The same procedure was carried out on the left side with the removal of about 16 mm. of the mandible. The upper and lower jaws were then partially fixed by the use of rubber bands.

Rubber dam drains were placed in each external incision and the mucous membrane wounds were closed with catgut sutures. The skin wounds were closed with interrupted kaldermic sutures.

There was considerable discharge from the external incisions. The right side healed in a

few days. The left side discharged for almost two months although the x-ray showed no evidence of bone infection.

The patient was discharged to the Out-Patient Department and on July 1, 1937, complete consolidation was found to be present. (Fig. 26.)

SUMMARY

The major deformities of the mandible can be classified under three distinct groups:

1. Those in which there is loss of bone with the continuity of the mandible definitely disturbed.

2. Those in which there is maldevelopment and retrusion of the mandible.

3. Those in which there is overdevelopment of the mandible, such as occurs in prognathism and "open-bite."

The main causes of loss of bone in the mandible are osteomyelitis, trauma (especially gun-shot wounds), and surgical intervention for the removal of growths. The general outline of treatment consists of transplantation of bone and the construction of prosthetic appliances. Transplantation of bone is the desirable procedure whenever it is considered practical. The writer prefers osteoperiosteal grafts, even in large defects.

Prosthetic restorations have a definite place in the restorative treatment of the mandible. Their main function is to hold the remaining segment of the mandible in normal position, in order that the existing teeth may perform their masticating duties.

Symmetrical bilateral retrusion of the mandible may be due to birth injury, trauma, infection involving both sides of the mandible, or bilateral ankylosis at an early age. The treatment consists of advancing the anterior part of the lower jaw by making a diagonal or L-shaped incision on each side of the mandible.

Asymmetrical retrusion of the mandible shows the chin markedly retracted and one side of the mandible shorter than the other. The correction of such deformities involves lengthening the short side of the mandible, supplemented by transplantation of bone or cartilage to obtain prominence of the chin.

Prognathism of the mandible and "open-bite" form a definite type of deformity. Prognathism is treated by two methods. First, by the removal of a measured section of bone from each side of the body of the mandible and pushing it back into its new position; or second, by cutting through the ramus and holding the entire lower jaw in the new position. The relative merits of these two methods are discussed in detail. Previous to operation, it is necessary to make preparations in the form of measurements and dental splints, or postoperative treatment in the form of orthodontic work or other dental treatment may be required.

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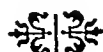
PLASTIC RECONSTRUCTION OF THE FEMALE BREASTS AND ABDOMEN

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WHILE in the last half of the past century French surgeons occasionally alluded to plastic procedures on the breast, it was Girard who in 1910 called specific attention to this type of reconstruction work. He compared pendulous breasts with floating kidneys, pointing out that just as a prolapsed kidney calls for occasional suspension, so should pendulous breasts, when indicated, be suspended (mastopexy).

Virginal hypertrophy, unequal development, pendulous and hypertrophied breasts call for surgical intervention because the excessive weight frequently causes circulatory disturbances and impeded lymph circulation followed by a chain of complaints of greater or lesser severity. Already Velpeau many years ago, spoke of this condition as "engorgement hypostatique." A multitude of operations have been described for its correction.

The causes for enlargement of the breasts are: accumulation of fat, insufficiency of the suspensory apparatus and, to a minor degree, hypertrophy of the glandular structure. It is the excessive accumulation of adipose tissue which plays the predominating part. Some authorities are of the opinion that the fat accumulated in hypertrophied breasts differs in composition from ordinary adipose tissue. Hypertrophy sometimes occurs before menstruation sets in, but is more frequent after that period, and may occur at any time. The endocrines and genital function play an important rôle. Küster once saw a patient in whom hypertrophy of the breasts followed irradiation of the pelvic organs following an abortion.

It must be recalled that the suspensory apparatus of the breast is not always found as described in textbook diagrams. The suspensory arrangement of the breast was first described by Sir Astley Cooper. Giraldé speaks of a ligamentum suspensorium mammae which forms a special division of the superficial thoracic fascia, beginning at the clavicle and extending to the superior border of the breast where it divides into an anterior and posterior sheath which envelops the breast. It is on this basis that the synchronous movements of the breast with those of the shoulder girdle are explained. Testut (cited by Girard) observed that this suspensory ligament is at times well developed and at others just slightly indicated. It is most pronounced on the posterior surface of the breast, but in practice is sometimes difficult to demonstrate. Küster believes that the principal factor in suspending the breast is the skin covering it, which sends into the gland structures, fibrous tissue septa in a comb-like manner. The posterior surface of the breast is connected to the pectoral muscle by means of a layer of very loose areolar tissue, whose object, however, is to permit greater mobility. This plays a minor rôle in suspending the breast. It is apparent that the weight of a large accumulation of fat and fibrous tissue in the breast so stretches the suspensory apparatus that the breast descends and prolapses. The degree of such prolapse depends upon the degree of tissue accumulation. Hypertrophy of the breasts is often observed while the rest of the body remains in perfectly normal proportions. Loss of weight through diet and medical means may, on occasion, be in a measure effective to reduce the breasts, but it creates into the bargain an unesthetic condition of flap-like skin bags, the erstwhile housing of the fat, which I have described as "reduction bags."

In pendulous, congested breasts the question is no longer one of pure esthetics, but also one of correction of a pathologic entity causing actual physical distress (drawing pains, oppression, tension, intertriginous eczema, psychic depression, inferiority complexes, etc.). Kyphosis frequently results from an attempt of the patient to equalize the weight produced by the pendulous breasts through constant bending backward. As Axhausen so aptly expresses it "Hypertrophy of the breasts in young individuals is not an esthetic condition purely; it is often a serious disease condition."

Hypertrophies of the breast vary in extent. In some instances the breasts may reach below the umbilicus. (Fig. 1.) These are not always concommitants of general adiposity; as stated, the entire body may be normal, the abnormality being limited to the breasts.

The ideal results one aims to accomplish in plastic reconstruction of the breasts are:

1. The newly reformed breasts must be situated in their normal position.

2. They must be able to function (endocrinologically).

3. They must have the form and size of the normal breast and no injury to the blood and lymph vessels must result.

4. The scars should be as inconspicuous as possible.

5. Both breasts should be symmetrical. All of these can be achieved by proper technique, but the function of lactation can only rarely be maintained.

Reconstruction operations on the pendulous breasts may be divided into four principal divisions:

1. Procedures aiming to suspend the breast (after proper dissection) to the costal cartilage of the second or third rib (Girard).

2. Transpositions of the nipple with remodelling of the breast tissue (Lotsch-Kraske, Axhausen and others).

3. The third variety, of which the Lexer-Holländer and Joseph operations are representative, consists of an incomplete detachment of the connections between the

breast, nipple and skin-covering, followed by reconstruction of the form of the breast by excision of the required amount of

FIG. 1. Hypertrophy and pendulosity of the breasts; nipple extending below the umbilicus and into the groin when the patient is in a sitting position. Otherwise normal body configuration.

tissue, and finally by proper flap placements. These are the two-stage and occasionally three-stage operations (Joseph).

4. Transplantation of the nipple with plastic reconstruction of the breast (Thorek).

Professor Axhausen, in 1926, in evaluating the various methods, questioned the fate of transplanted nipples as described by myself. Axhausen adds (loc. cit.) "If this important question could be answered in the affirmative it would then certainly be better to resort to Thorek's operation than to court a possible necrosis of the nipple, should there occur a mishap by reason of a technical error in performing a Lotsch (transposition) operation." I have since proved that the fears expressed by Axhausen are unfounded and that properly transplanted nipples do unite to subjacent structures (vide infra).

The blood supply of the female breasts springs from the following sources: (a) the lateral thoracic artery, a branch of the intercostal spaces and the pectoral muscles; these also divide into two branches which approach the breast from behind and are
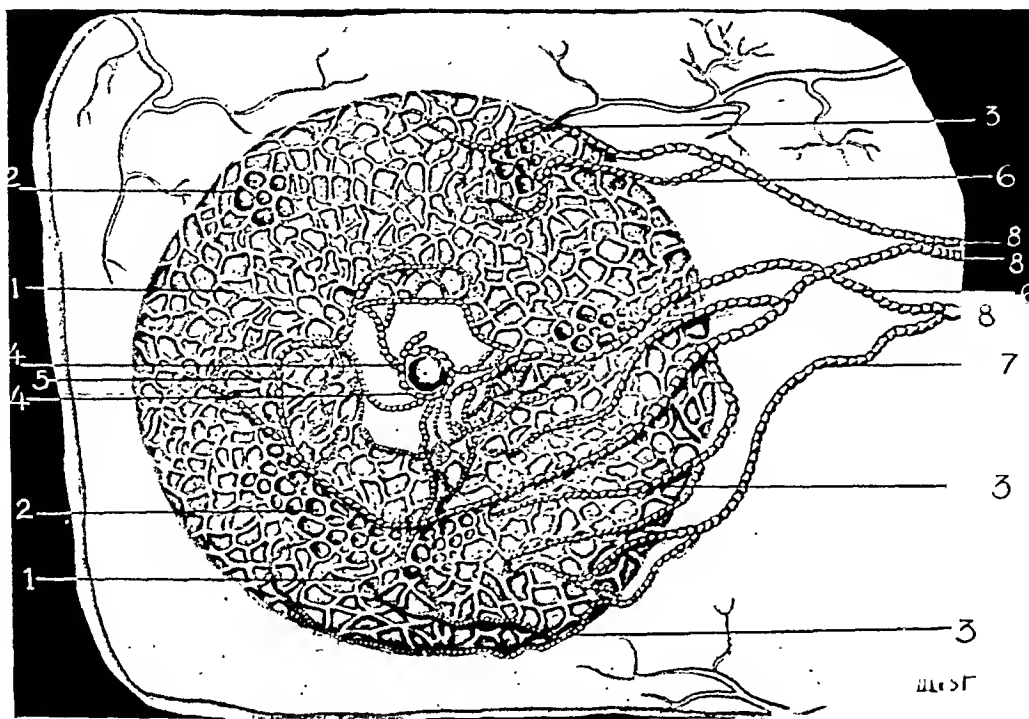
Fig. 2. Lymphatics of the female breast. 1, 1, lymphatic network of the anterior surface of the mammary gland. 2, 2, lobules of the mammary gland, the peripheral lymphatic network of which has not been injected, in order to render more prominent the circumlobular network which surrounds the lobules. 3, 3, trunks which arise from the upper and lower portions of the mammary gland. 4, 4, lymphatic plexus under the areola. 5, lymphatic vessel which arises from the internal part of this plexus and which takes a semicircular course to reach the axilla. 6, another vessel arising from the outer part of the same plexus and running directly outward. 7, lymphatic vessel arising from the lower part of the gland and uniting with the preceding to form one of the two trunks into which all the other vessels empty. 8, 8, vessels arising from the internal part of the subareolar plexus and from the upper portion of the breast converging to form the second of the two trunks which empty into the axillary lymph nodes.

axillary artery; (b) from the internal mammary artery, a branch of the subclavian artery; (c) the perforating branches arising from the third to the seventh intercostal arteries. The largest of these is the lateral thoracic artery which courses along the lateral side of the chest and divides into two or three branches, winding its way to the outer half of the breast which it supplies. The second largest blood vessel is the internal mammary artery which also divides into two or three branches and courses mesially toward the median half of the breast which it supplies, particularly its central glandular portion. Besides these, there are the arteries which penetrate the

responsible for the blood supply of the deeper, central portions of the breast. In the breast tissue the arterial trunks accompany the galactophorous ducts. The nipple and its areola are for the most part supplied from branches of the intercostal and the internal mammary arteries. The lateral thoracic artery, the largest of the group, does not take part in the blood supply of the nipple, but assumes the responsibility of supplying the outer half of the breast and its surface. Generally, the veins follow the same course as the arteries. Besides these, there is a network of large veins which run subcutaneously and are often visible. These empty into the axillary vein. The

lymph vessels (Fig. 2), represented in a very rich lymphatic system, unite as enlarged trunks on the lateral side of the

FIG. 3. Necrosis of breast and nipple resulting from attempted plastic surgery by inexperienced operator.

thorax and, coursing along the lateral border of the pectoralis major muscle, finally empty into the axillary lymph nodes.

The blood supply plays a very important rôle in plastic surgery of the breast. If the branches of the internal mammary artery are encroached upon, or, if on the lateral aspect, vessels entering the breast from the axillary line are injured, necroses may result.

As to the function of the breasts, it is well known that hypertrophied breasts are of little value as far as lactation is concerned. Such breasts are functionally inactive organs. It has been shown by many authors that women with hypertrophied breasts who have given birth to children often find that they are unable to nurse them (Girard). Thus the impression that large breasts denote good function is not based on fact.

The term "plastic surgery" has justly grown into disfavor with general surgeons in many quarters because of its abuses by

FIG. 4. Transplantation of the nipple. Low power magnification. The nipple structure is intact. Round cell infiltration in the immediate vicinity. There is one isolated area (x) of an epithelial nest of cells, the result of introducing microscopic portions from the skin during the operation.

charlatans and by some surgeons who lack knowledge or training in this type of work. This criticism is frequently justifiable. Plastic reconstruction of the breasts requires, besides a thorough knowledge of anatomy and physiology of the structures concerned, a high degree of mastery of technical details. Figure 3 shows the results of attempted plastic surgery by an inexperienced operator. Such cases are regrettable and often represent not only downright lack of surgical conscience but bungling attempts bordering on the criminal.

It is refreshing to note that in certain universities chairs for the teaching of plastic surgery have been or are being established in order to wrest from the hands of

impostors a branch of surgery in which special qualifications are a sine qua non. The benefactions of plastic surgery have

FIG. 5. Transplantation of the nipple. Higher magnification of the corium showing round cells, a few polymorphonuclears and some plasma cells.

been manifested in the remarkable advances in facial plastics following the World War and also in reparative work on individuals who by reason of modern demands (avocations) and physical handicaps resulting from pathologic malformations have insisted that the well-trained surgeon affords them relief. To repeat, in plastic reconstruction of the female breast, it is not sufficient to possess an accurate knowledge of anatomy and physiology alone; such knowledge must be backed up with thorough special surgical training. Also, it is essential that the surgeon possess a definite sense of innate artistry because this type of surgery represents "surgical artistry" or "sculpture" (if the term may be permitted) of a very high order.

When these patients are turned down by the surgeon who, because of lack of understanding or training assumes a *laissez faire, laissez mourir* attitude, they often drift into the traps of the charlatan. The woman with marked hypertrophy of the breasts finds herself burdened with a physical, social and mental handicap. It is easy to understand how such a person, particularly if possessed of a high esthetic sense or forced into frequent business contacts or public appearances (business women, speakers, singers, artists, etc.) would suffer keenly both physically and psychically because of her affliction. The mental depression suffered by such individuals often manifests itself in the form of a more or less marked inferiority complex which frequently causes the victim to withdraw from social contacts. I recall a patient who, by reason of brooding over her ponderous breasts, was committed to an asylum. The psychosis was relieved after successful reconstruction of the hypertrophied breasts.

A perusal of illustrations depicting "good" results of some operations betray in some instances that the final result is represented by a retouched negative and appears satisfactory. In some of such illustrations without the aid of the retouching pencil the results are discouraging. Retouched negatives have no place in scientific illustrations.

The patient has a right to demand the very best possible esthetic result. Surgeons who have had experiences with all methods described have reached some rather definite conclusions.

It was Morestin who, in 1907 and later in 1933, described a method of discoid resection of the hypertrophied breast. Passot's method consists of transposition of the nipple. In principle, the method consists of making a circular incision around the nipple and areola; to use the expression of Passot "une incision circulaire perimamelonnaire." A second circular, or as some prefer, oval, incision is marked out with silver nitrate higher up on the breast at the point at which the transposition of the nipple is to be effected. A portion of skin

Fig. 6. Beginning of separation of discolored horny layer of the skin of the nipple underneath which normal regenerated tissues persist.

Fig. 7. Same patient, horny layer separated. Nipple satisfactorily healed.

Fig. 8. Virginal hypertrophy and pendulous breast. Before operation.

Fig. 9. Same patient one month after operation. Observe nipples after healing. Compare with Figures 6 and 7.

corresponding to the outlined circular or oval area is removed. At the upper border of the nipple and tangential to it,

FIG. 10. Abdominal adiposity.

a horizontal incision is made, the ends of which meet another curved incision which is made in the crease on the under surface of the breast. This incision is similar to the Gaylord-Thomas incision for the removal of certain types of tumors. The skin between these two incisions is excised. Now the lower portion of the breast structure lies exposed. Following this step, the skin above the nipple is loosened in a tunnel-shaped manner. Through the tunnel thus constructed the nipple is grasped with appropriate forceps and pulled up into the previously created oval or circular opening where it is fastened by means of interrupted sutures. It is of utmost importance not to exert too much pressure on the galactophorous ducts after the structures are reunited. Failure to observe this precaution will lead to necrosis of the nipple.

The next step of this operation consists of resecting the lower segment of the breast. By means of an oblique incision a wedge-shaped resection of as much of the

breast tissues as is necessary is performed. This resection should extend down to the retromammary space. Following careful
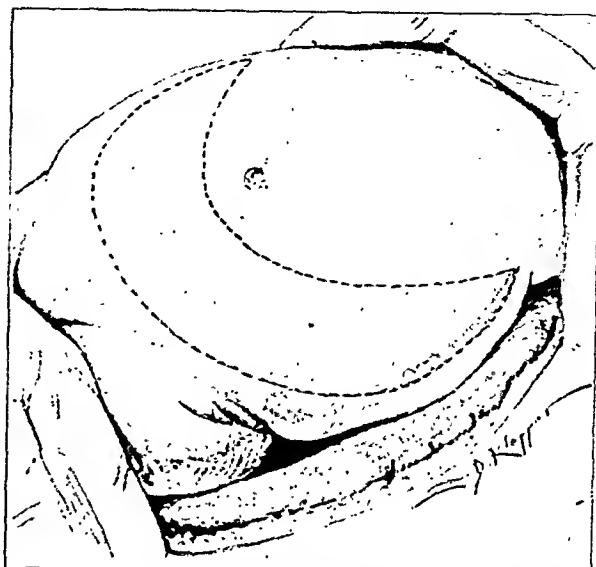
FIG. 11. Author's crescentic incision in abdominal adipectomy. (From Thorek in *M. J. & Rec.*, November 15, 1922.)

resection, meticulous skin suture, using clips or linen sutures, completes the operation. Continuous sutures should never be used in the final step of this operation.

Duformentel, Lotsch, Axhausen, Lexer, Kraske and many others have made modifications of the transposition of the nipple operation of which the above described Passot procedure is the foundation. Joseph, as already stated, operated in three stages to avoid necrosis of the nipple.

In an address before the North Shore Branch of the Chicago Medical Society in 1921 I first showed that it is possible completely to disconnect the nipples and areolae from their subjacent beds and transplant them to a new position in the remodelled breast.

My operation of plastic reconstruction of the breast with transplantation of the nipple is accomplished by outlining the incisions to be made with an alcoholic solution of brilliant green a day or two before the operation, with the patient in the sitting position. The outlines must be symmetrical, allowing rather for a little

more flap than too little, thus avoiding the embarrassing situation of having fashioned the skin flap too small.

FIG. 12. Patient shown in Figure 10 three weeks after plastic adipectomy (lipectomy).

Selection of a "new position" for the reception of the disconnected nipple at the proper level of the breats, at the same time reshaping the organs to their natural contours following resection of the excessive mammary tissue, is next to be accomplished. With proper technique, disconnection and free transplantation of the nipple, aiming at careful avoidance of injury to its highly specialized tissues, necrosis may be avoided and satisfactory vascularization and taking of the nipple may be anticipated with confidence.

AUTHOR'S OPERATION

The steps of the operation may briefly be outlined as follows:

1. A supra-areolar convex incision is made over the outline previously made with brilliant green on the surface of the hypertrophied and pendulous breast; a second, similarly directed, incision is made in the submammary crease beneath the global mass.

2. Remove between these two incisions as much glandular and adipose tissue as is deemed necessary to obtain the desired size and equality of breast contour.

3. Perform free circular detachment of
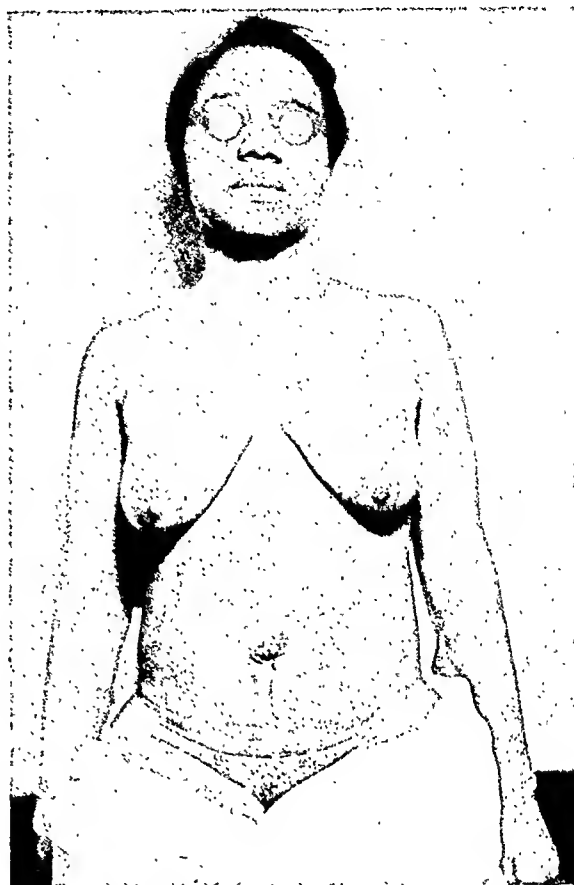
FIG. 13. Transplantation of umbilicus nineteen days after operation. Hysterectomy for fibroids and umbilical hernia.

the nipple and areola through a circular superficial incision. The subdermal tissues of the nipple must be treated with utmost gentleness.

4. Transplant the nipple into a bed prepared at the site previously selected.

5. Adaptation and suture of the flaps. Here utmost care is to be exercised. Incorrect adaptation of skin flaps will lead to unsightly projections, particularly at the corners of the wounds. "Rounding the corners" consists of removing the projecting skin portions with curved scissors, the concavity of which faces the projection. This is to be followed by careful suturing of the wound edges with interrupted Pagenstecher linen. Skin clips may be used.

Meticulous hemostasis is of prime importance. Of course, no drains are used. Light compression dressings should be employed.

Surgical artistry and special technical skill are requisite for this operation if one aims to obtain well formed breasts and to avoid unsightly lumps and disfiguring scars. In the vast majority of my cases thus treated, the cosmetic results were excellent and there was no doubt regarding the viability of the freely transplanted nipple and areolar tissue. I have even had an opportunity to obtain complete histologic verification of this statement.

In 1930, a woman on whom I had executed a plastic operation on the breasts with nipple transplantation, came under my care two months later for another surgical condition. With the patient's consent and definite understanding of the reasons, a small section of the transplanted nipple was removed for biopsy, which gave the following histologic results:

The epithelium was found intact and the corium containing round cells with few polymorphonuclears and some plasma cells. As is seen in Figure 4, there is an isolated islet of epithelial cells, in all probability due to the implantation of some epithelial cells, the result of pinching them off during the process of operative transplantation. Following the acute reactionary process, the cell metamorphosis transgressed into the subacute phase, as is evidenced by some polymorphonuclear and a more extensive round cell infiltration. When this area is examined under high power magnification, one observes the epithelial strata intact and immediately below this area, in the corium, some round cells, plasma cells and a few scattered polymorphonuclear leucocytes. The cellular elements and the capillaries in the corium may here be closely studied. (Fig. 5.)

From these findings, it is quite evident that the transplanted nipple and areola have become vascularized and incorporated in the new site, as normal, living tissue. It is further shown that the operation of resection of superfluous tissue in hypertrophied pendulous female breasts, with free transplantation of the nipple and areola, is a practical procedure, and that, when carried out with proper technique, it will result not only in relief of the patient's disability, but also in a satisfactory configuration from the standpoint of esthetics and of permanency. The transplanted nipple does not become absorbed nor die, but continues as normal, vascularized, living tissue, in the vast majority of cases.

If, a few days following the transplantation of the nipple the surface of the latter appears dark or even black in color, but transplantation is not necessarily unsuccessful. Such phenomena do not signify failure of the nipple to take. On the contrary, in most cases, if not in all, where the technique has been faultless and the postoperative care proper, the superficial, discolored layer, representing only the stratum corneum, exfoliates, while the cutis vera goes on to healing per primam. Figure 6 depicts the beginning of the separation of the horny layer of the skin, while Figure 7 shows the same transplanted nipple after healing is complete. They are from the patient shown in Figures 8 and 9. It may take a few weeks for the stratum corneum to separate. This, however, in no manner hinders the patient from pursuing her usual business or other activities. The keynote to the postoperative treatment consists of dry asepsis (desiccating powders and sterile supportive dressings).

Careful individualization and planning of the operation are necessary to obtain good results. A great deal depends on the experience and skill of the surgeon as well as the coöperation of the patient in the pre- and postoperative care. One must ever be mindful that lack of knowledge of the subject, improperly selected cases and inadequate pre- and postoperative care may result in sloughing, abscess formation and other complications.

ABDOMINAL ADIPOSITY

So-called "fat aprons" are divided by Küster into the following varieties:

1. *Venter propendens:* in these cases only the skin and its adipose content are involved.

2. *Venter extentus:* here the suspensory apparatus of the abdominal wall is overstretched. (Fig. 10.)

Fatty accumulations may be situated (1) above the umbilicus; (2) below the umbilicus; or (c) in both situations. Both "fat aprons" and pendulous breasts may affect the same individual. "Fat aprons" may be of such magnitude as to interfere with the patient's vocation and comfort. They may appear in combination with hernia.

The incision I have described for remedying this condition surgically is depicted in Figure 11. In performing this operation (plastic adipectomy; lipectomy) a small sharp amputation knife is preferable to a scalpel, since it makes a smoother incision. The direction of the incision toward the abdominal fascia is important. It should always be directed obliquely so that both incisions meet at an apex on the fascia; straight incisions leave a wide surface of fascia exposed which is difficult to close. "Dead spaces" and ugly scars result; besides, such incisions invite infections, hernias, etc.

In operation on "fatty aprons," the skin must be properly prepared and be free from excoriations, acute inflammations, intertriginous eczematous conditions or other skin disease. As few ligatures as possible should be used, and preferably none at all. In the latter instance hemostasis is accomplished by electrocoagulation by grasping the bleeding vessels with an artery forceps and touching the latter with an electrode fed from a diathermy apparatus. For skin sutures, Pagenstecher linen, silk or clips may be used. Drainage for twenty-four hours at the angles of the wound is occasionally called for. Excellent results follow in properly planned and carefully performed lipectomy operations. (Fig. 12.)

Many people are sensitive to the loss of the umbilicus in operations for "fatty apron" which require its ablation, such as those complicated by umbilical or ventral hernia. In such cases, I reimplanted the removed umbilicus (Fig. 13). Someone has expressed the thought that an abdomen without a navel is like a face without a nose. The umbilicus is a resting point for the eye in regarding the longitudinal measurements of the body. Various superstitious and religious beliefs also play an important rôle in this regard. A Negro patient of mine at Cook County Hospital refused to be operated on for an umbilical hernia unless he could be assured that his "belly button" would not be touched. It was this case that gave me the impetus for experimental work in transplantation of the umbilicus. I have failed to find any reference in the literature to previous transplantations of this type. The technique consists of freely removing the umbilicus with the fat apron en masse. The umbilicus and a small layer of surrounding fat are dissected from the fat mass and placed in a container filled with normal saline solution until needed for reimplantation. After the necessary operation has been completed and the wound sutured, a space corresponding to the size of the detached umbilicus is left for the reception of the latter. It is sutured in place with interrupted linen sutures, care being taken that no dead spaces are left between the transplanted umbilicus and the bed into which it has been sutured. Instead of completely detaching the umbilicus, one may permit it to remain attached to the subjacent structures by a pedicle to be sutured in place after completion of the operation.

SUMMARY

Plastic reconstructive operations on the female breast and abdomen have been analyzed and various methods evaluated. Ethical, esthetic, as well as technical requirements in this field of work have been stressed. The value of the author's operation of plastic reconstruction of the breast with transplantation of the nipple has been reëmphasized. The author's

methods of plastic abdominal adipectomy (lipectomy) and reimplantation of the umbilicus have been described.

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THE new growths of the breast may be classified thus:

	Epithelial	Connective Tissue	Mixed
Benign	Duct papilloma / Pure adenoma	Fibroma / Lipoma	Fibro-adenoma / Cystadenoma
Malignant	Carcinoma	Sarcoma	Teratoblastoma

RECURRENT DISLOCATION OF THE SHOULDER*

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Definition. Recurrent dislocation of the shoulder means a repeated displacement of the head of the humerus out of the glenoid fossa. Although not a common condition, it is one which occurs often enough to demand careful consideration and treatment. Tavernier[24] draws a distinction between habitual dislocation which occurs "at the slightest provocation," as each time the arm is completely abducted, and recurrent dislocation, which may occur several times but only as a rule upon rather severe trauma. In the former type, operative treatment is more imperative than in the latter.

Types. The dislocations may be classed as to the anatomic displacement of the head, and conform to the general types of single dislocations. It is not necessary to go into detail as to the various displacements, as this information may be found in many textbooks on anatomy, surgery or orthopedics. In general, there are two types to deal with, the anterior dislocations which are usually subcoracoid, and the rare posterior dislocations.

Etiology. As to the etiology, there is practically always a history of severe *trauma* in the initial dislocation which has been followed by inadequate subsequent protection. Henderson[9] cites only one case where the initial dislocation occurred without trauma—that of a man who raised his arms while jumping a fence. There may be equally severe injury in the second dislocation, but thereafter the condition is likely to happen without trauma or violence. These subsequent dislocations may occur from simple movements as raising the hand above the head, reaching forward, or rolling over in bed, even when asleep. One of my recent up-to-date cases was that of a P.W.A. worker who raised a pick above his head. (But this might be put in the category of unusually strenuous acts!) These dislocations are easy to reduce as a rule.

Predisposing Causes. Predisposing causes are occupations which frequently expose the patient to violence or falls. Athletes, especially football players, are prone to this condition. Many cases occur in epileptics. Males are oftener affected than females, at least in the proportion of two to one. Most cases occur between the ages of 20 and 40, but they may occur at nearly any age. The duration of the condition before treatment (operative) has been recorded as from six months to twenty-five years, and the number of dislocations in one person from two to forty.

It has always been considered that the dislocation occurs with the arm abducted. Bankhart[2] says that it occurs from direct trauma to the back of the shoulder. However, the fact that recurrences are prevented by chaining the arm to prevent abduction would seem to indicate that abduction of the arm is a predisposing cause. I can find no record in the literature of anyone agreeing with Bankhart, and Speed forcefully disagrees.

Pathology. Many anatomic changes or defects have been listed as reasons for recurrent dislocation. Several agree that there is a defect in the head of the humerus caused by the initial displacement with its trauma. This change of the bone allows subsequent luxations to occur more readily. Some French authors claim that there is a congenital malformation, but to this Henderson[9] does not agree. There is usually a slight atrophy of the deltoid. Defects of the glenoid fossa may be present, or a

laxness of the anterior inferior part of the capsule. These dislocations are hard to produce by passive motion even "in a habitual case under an anaesthetic." Henderson thinks voluntary muscle action is necessary. Speed,[21] quoted by Codman[6] lists the causes of recurrent dislocations as:

1. Defect in the head of the humerus acquired at the first dislocation or congenital.

2. Defect of the glenoid, acquired from fracture of its edge, or congenital shallowness.

3. Rupture of insertions of external rotators of the head of the humerus.

4. Avulsion of the tuberosities with or without the preceding.

5. Detachment of capsule from anterior lip of glenoid.

6. Enlarged joint from relaxed capsule from tears with insufficient time for cicatrization, or repeated stretching without tears.

And Codman adds:

7. Failure of neuromuscular coördination.

On the other hand, Bankhart[2] says, "None of these causes has been present in any of (my) twenty-seven consecutive cases. . . . Recurrent dislocation has nothing to do with ordinary traumatic injury. Ordinary dislocation is caused by a fall on the abducted arm, but this dislocation is caused by a fall either directly on the back of the shoulder or on the elbow which is directed backwards and slightly, if at all, outwards. The head of the humerus is forced out of the joint not by leverage, but by a direct drive from behind forewards." This shears off the fibrous or fibrocartilaginous ligament from its attachment to the bone. He states that he exposed this lesion in all of his twenty-seven consecutive cases.

Symptomatology. The chief symptoms are a feeling of insecurity and apprehension. At the first dislocations there is the accompanying pain which may be very severe and last until reduction takes place. A dull ache may continue for some time thereafter together with a feeling of stiffness. In the recurrent dislocations which I have seen the pain has been excruciating each time. In the so-called habitual dislocations after many repetitions there may be very slight or no pain, and the victim may be able to produce a dislocation at will, more often without willing. These humeral heads may slip out during sleep. Usually the patient is in some distress until reduction is done. I have seen them at night in considerable pain and demanding immediate replacement of the head, sometimes under anaesthetic at the hospital. When this is done the patient usually feels so good that unless made to take care of his bill immediately he forgets his late distress and will complain more about the bill sent for services, however small, than he did about the original distress!

TREATMENT

The treatment consists of (a) prevention and (b) reconstruction. *Prevention* of recurrent dislocations consists in taking care of the primary dislocation to allow healing of the capsule. At the primary dislocation no ill-advised or unintelligent attempts at reduction should be made by any bystander, pseudo-medico or the laity in general. If possible before reduction is made an x-ray should be taken to rule out or show an accompanying fracture. Occasionally a mild fracture may be produced or converted into a severe one by injudicious attempts by over-zealous citizens whether licensed or no, to put something, almost anything, back into place. At best an x-ray and then careful gentle attempts at reduction of the dislocation without anesthesia, followed if unsuccessful by reduction with care under an anesthetic. Immediately following replacement the arm should be placed in the Velpeau position and fastened there by bandage and adhesive. Occasionally in the ignorant, perverse or foolish—as "in children, athletes and idiots," not to mention a certain pseudo-scientific and non-semitic cult, a plaster of Paris Velpeau should be applied. This restraint should be worn for ten days without removing and

should be reapplied after careful manipulation for at least another ten days. After that it would be well to use a Sayre bandage to prevent abduction for another three weeks. This will give the capsule a chance to heal before a recurrence takes place.

In those who have had recurrences, the wearing of some apparatus to prevent abduction will usually safeguard the shoulder from dislocation.

Reconstruction. When recurrence of dislocation has been established some form of reconstruction operation is the only hope of cure. There are many kinds of operations used by many different surgeons none of which has been proved to be 100 per cent efficient. Codman[6] believes that it would seem that a patient stands some chance of cure by any of these methods and advises that the simplest be chosen since his chances of recovery are as good as if he had the most complicated one. In this I do not agree, since certain operations whether simple or complicated have been proved more satisfactory than others.

The operation should be suited to the type of lesion and the individual's habits. Where a simple operation like the modified Nicola will hold in most instances in ordinary life, the "combination operation" or some of the special ones would seem indicated in those subjected to severe trauma as in athletes, heavy workers, epileptics, etc. An operation in the hands of a surgeon who devised it and has done several is more likely to succeed than when done by an occasional operator for the first time.

Classification of Operations. The operations may be classified as to their types from the structures used. This list is by no means complete.

1. Operations on the bony structures.
   (a) Deepening of the glenoid from behind (Hildebrand[11]).
   (b) Bone graft at margin of glenoid (Eden,[7] Speed[21]).
2. Operations on the capsule.
   (a) Anterior capsulorrhaphy (Ricard,[19] Henderson,[9] Albee,[1] MacAusland[17]).

   (b) Capsule repair (Bankhart[2]).
3. Muscle transference and muscle lengthening (Clairmont,[5] Ryerson[20]).
4. Suspension operations (Spitzy,[23] Carrell,[4] Henderson,[10] Fowler[8]).
5. Biceps tendon operation. (Nicola,[18] Roberts quoted by Burnet[3]).
6. Combination operation. (Hobart[13]).

Choice of Operation and Prognosis. Each of these operations has been described at length in the literature so that it is unnecessary here to go into the details. Reference numbers have been placed after the names in order that the technique of the operation may be found readily in the literature. Some of them would seem rather difficult technically, although in the hands of the originator they may be quite feasible.

In order to evaluate the success of the different operations and to bring this matter up to date, correspondence has been had with surgeons whose articles have appeared in the literature from time to time, on this subject. Replies were received from seven out of twelve so addressed.

Fred Albee, New York City: "I have operated on a large number of cases for recurrent dislocation of the shoulder. Formerly, I did an operation which was a modification of the old Burrell operation of reefing the capsule at or near the tear. . . . In recent years I have done the Nicola operation, the technique of which is much simpler. I have had a great deal of satisfaction in the success gained by this procedure. I have done about thirty-three Nicola operations with but one recurrence."

Kellogg Speed, Chicago, within recent years has operated upon twenty-two recurrent dislocations of the shoulder, fifteen by the Nicola method, seven by the bone block method. Every effort has been made to follow these patients up and there have been no known recurrences. "It is my opinion that the Nicola operation suffices for most uncomplicated cases. The bone block procedure I have always reserved for patients with bony deformities of the glenoid rim, or established epileptics, or in

others with gross deformity of the head of the humerus where it was felt that the tendon suspension might be inadequate."

Edwin W. Ryerson, Chicago, has done ten Clairmont-Ehrlich operations, two fascia lata suspensions, and three Nicola operations. "There have been no recurrences, so far as I know: although one case of Nicola's operation claims that the shoulder feels somewhat insecure and is at times painful."

W. B. Carrell, Dallas, Texas, prior to 1936 operated on about fifteen cases of recurrent dislocation of the shoulder by the method he described in the literature.[4] One was an epileptic, several were football players. No recurrences occurred, nor any complaints of shoulder limitation; no patients were prevented from resuming their former occupations. During the past few years he did the Nicola operation "because it was sound in principle and much easier to do. There were six or eight of these Nicola operations, and we have had one recurrence." This last was a fairly recent case, a football player, who returned to football without permission under the ninety day period. "My impression," Dr. Carrell writes, "is that the Nicola operation is adequate for restoration of good stability, but at the present moment I am inclined to believe that I will return to the fascial sling combination which I formerly did for heavy athletic individuals."

Nicola,[18] in 1934 said that he performed thirty-seven of his operations with one recurrence.

MacAusland,[17] in reefing the capsule in five cases with six operations, reported four without recurrence although two of these had weak shoulders, one with one dislocation since operation and one failure.

Thomas[22] had twelve successful results in eighteen capsule pleating operations.

Henderson[10] reported twenty-seven cases of his tenosuspension operation with three recurrences in 1935. Since then he has done fourteen more tenosuspension operations without recurrence. He says, "I am still using the tenosuspension operation, though

many men, I know, are using the Nicola operation; inasmuch as these cases are rare I think it is better to stick to our own method and follow it through so that we will know its true value."

E. A. Codman, Boston, writes: "I have not operated upon a case of recurrent dislocation of the shoulder for years. The few I have done all recurred and so *I have advised against operation* and in favor of exercises to develop internal rotators. . . . From what I hear even the Nicola operation is not the last word."

Horwitz,[14] in 1936, reported twenty-five cases of the Nicola operation. He left five out of his summary because of too recent operation. Of the other twenty there were three recurrences. He concludes that the Nicola operation *properly executed* corrects the disability of a recurrently dislocating shoulder joint and that failures are due to improper technique or overly severe trauma.

DeForest Willard[26] reports ten Nicola operations with only one recurrence and that due to severe trauma.

Koster[16] operated upon three cases by the Nicola method in 1936 without recurrence.

My series of seven cases includes one Clairmont, two modified Nicolas,[12] two combination operations (modified Nicola and Clairmont) without recurrence,[13] one original style Nicola in which the patient claims subsequent dislocations which immediately reduce of themselves, and one modified Nicola done too recently to say.

Roberts' operation in which the tendon of the long head of the biceps is roughened and sutured back in place after deepening the bicipital groove, is recommended by Burnet[3] as very satisfactory. He reports eleven cases with a follow-up of nine without recurrences; one is too recent to report and one did not answer.

Bankhart[2] reports no recurrence in his twenty-seven consecutive operations in which he "reattaches the glenoid ligament (or the capsule) to the bone from which it has been torn."

To summarize, then, the personal communications and the literature reviewed, although not complete, give a fair estimate.

easy to accomplish as any. It has also been used with success in those who are to continue in rough occupations or sports.
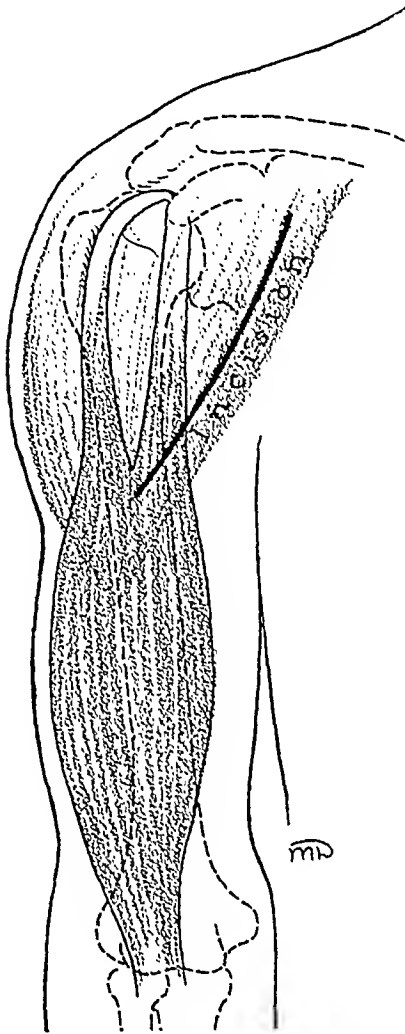
FIG. 1. The newly placed incision for the Nicola operation. (From Hobart, in *J. Bone & Joint Surg.*, 17: 1001, 1935.)
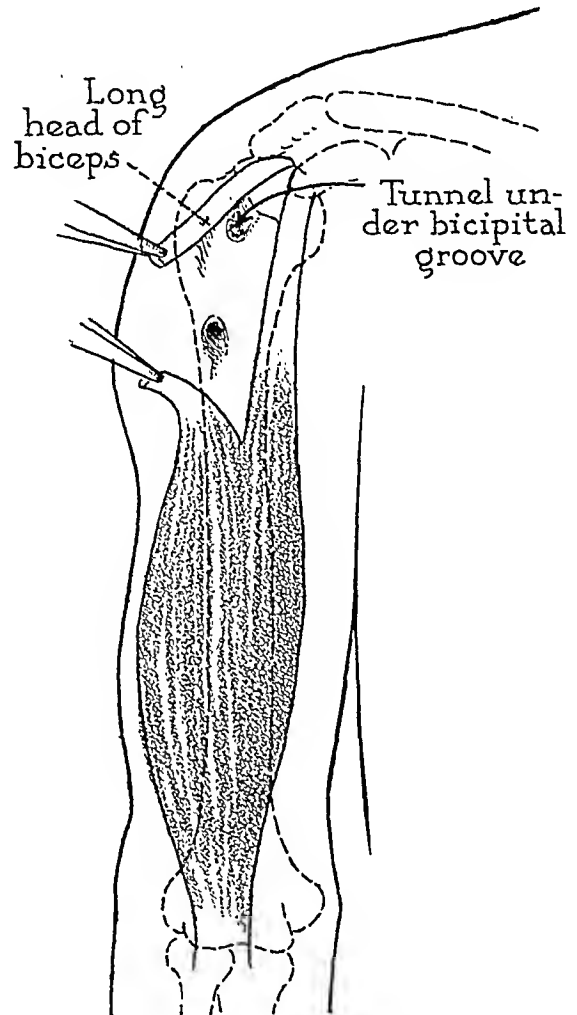
FIG. 2. The long head of the biceps is cut and a tunnel is drilled under the bicipital groove, without entering into the cartilage of the head. (From Hobart, in *J. Bone & Joint Surg.*, 17: 1001, 1935.)

The review gives 278 recurrent dislocations operated upon, as follows: 132 Nicolas with eight recurrences, forty-one tenosuspensions with one recurrence, seventeen fascia suspensions with no recurrence, nine Roberts operations without recurrence, seven bone block operations without recurrence, twenty-seven anterior capsule repair without recurrence, two combination operations without recurrence, forty-three Clairmont-Ehrlich operations with fourteen recurrences.

For most uncomplicated cases who are not to undergo future severe trauma the Nicola operation seems satisfactory and as

The Clairmont operation is highly recommended by Ryerson[20] who has used it with success in ten cases. He is very careful to detach enough of the distal part of the deltoid muscle or to supplement it with fascia lata so that it can be attached to the coracoid process. The difficult part of this operation is to induce the posterior strip of deltoid to go through the quadrilateral space and the chief danger is that in so doing the posterior circumflex artery or nerve be injured.

Henderson[9] who reported eight Clairmont operations with four failures said: "The frequent failures caused me to

abandon this operation." If successful, it is very satisfactory because of the full normal range of motion. Failures are due to the

FIG. 3. The long tendon of the biceps is placed in the tunnel and sutured to itself. (From Hobart, in *J. Bone & Joint Surg.*, 17: 1001, 1935.)

difficult technique and the tendency to degeneration of the distal portion of the muscle flap.

The combination of these two operations[12] so far as I know has been used only twice, each time with success (four and one-half years and three and one-half years without recurrence). The patients have played football, basketball, etc., with perfect function. This gives 100 per cent results, but enough cases have not been reported. I believe that it will continue to give 100 per cent results if carefully done. But it is at least twice as much work as either operation alone and therefore is recommended only for certain chosen patients.

Without reporting all the technique of
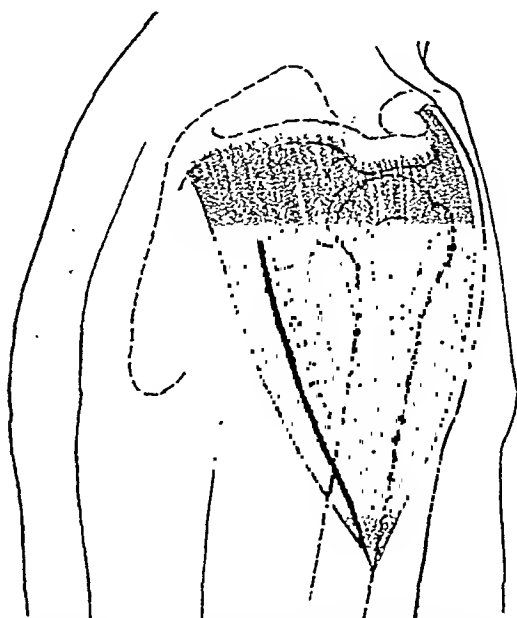
FIG. 4. The posterior incision for the Clairmont operation. (From Hobart, in *J. Bone & Joint Surg.*, 17: 1001, 1935.)

the special operations, perhaps it will suffice to describe the combination operation, as in most cases I believe the combination operation, or one of its parts, is sufficient.

THE COMBINATION OPERATION

In this method a Nicola operation with transplant of the long tendon of the biceps muscle through a tunnel in the head and neck of the humerus is done. When this operation is completed the Clairmont operation is added, in which a strip of the posterior edge of the deltoid muscle is drawn through the quadrilateral space and fastened to the anterior edge of the same muscle, or better to the coracoid process.[13]

Technique. Under ether anesthesia, a modified Nicola operation is done. With the patient on his back and the forearm flexed and pointing forward, an incision is made about 1½ inch posterior to the anterior border of the deltoid muscle, thus avoiding injury to the cephalic vein and allowing exposure of the bicipital groove and long

tendon of the biceps, without cutting any of the muscle fibers. (Fig. 1.) In an adult, this incision would be about 6 inches long.

FIG. 5. Completion of the Clairmont operation, with the posterior portion of the deltoid muscle passed through the quadrilateral space and attached to the anterior edge of the deltoid muscle. (From Hobart, in *J. Bone & Joint Surg.*, 17:1001, 1935.)

A fine, black, silk suture is placed through the biceps tendon, near its distal end, and the tendon is divided proximal to this suture, either obliquely or by a z-shaped cut. A second black, silk suture is placed through the cut distal end of the proximal piece of the tendon, and the ends of the suture are left long. With a ¼-inch drill, a tunnel, about 2 inches in length, is made underneath the bed of the biceps tendon. This tunnel is directed obliquely and so placed that the proximal aperture is at the junction of the cartilaginous edge of the head of the humerus and the proximal end of the bicipital groove. (Fig. 2.) This allows the long tendon of the biceps to be placed through the tunnel in an anatomic and physiologic direction, avoids any sharp angle in the tendon, and obviates crushing of the tendon between the head of the humerus and the glenoid fossa.

Next, the sutures in the proximal end of the biceps are threaded through the eye of a blunt probe. The probe is passed through the tunnel, drawing the sutures and the tendon gently through after it. The long tendon of the biceps muscle is sutured together carefully. (Fig. 3.) The wound is closed temporarily with a towel clip.

The second step consists of a Clairmont operation. With the patient propped up on a large sand-bag, an incision is made along the posterior edge of the deltoid muscle. (Fig. 4.) A strip of that muscle is separated about an inch anterior to the posterior border and freed from its attachment to the deltoid tubercle on the humerus. This strip of muscle is then passed through the quadrilateral space (care should be taken to avoid injuring the posterior circumflex artery and nerve) under the surgical neck of the humerus and fastened to the anterior border of the deltoid with sutures. (Greater security might be insured in this part of the operation if the strip of deltoid muscle were fastened to the coracoid process.)

The skin incisions are closed and a Velpeau bandage applied. A cast is then worn for three weeks. Motion is gradually

resumed, with careful physiotherapy. The patient can return to full duty in from two to three months.

SUMMARY

1. Definition, etiology, pathology, symptomatology and treatment of recurrent dislocation of the shoulder are reviewed.

2. The prognosis and choice of operation are taken up in detail.

3. Up-to-date opinions and results of the operations of several surgeons whose articles have appeared in the literature are recorded.

4. The Nicola operation seems to meet general favor as the operation of choice for ordinary cases of recurrent dislocation, although some surgeons favor operations which they have devised.

5. In those patients who are to be subject to severe trauma special operations, or the combination operation, should be used.

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ACROMIOCLAVICULAR DISLOCATION

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ANATOMY OF THE ACROMIOCLAVICULAR JOINT

THE acromioclavicular joint is the only union between the scapula and the clavicle and is a very important connecting link between the trunk and the upper extremity. This joint has an intra-articular meniscus, a capsule that is reinforced on its superior aspect by the strong acromioclavicular ligament, and as a peculiar feature, the fact that its main elements of fixation are far away from the articular surfaces.

The rupture or the experimental excision of the acromioclavicular capsule and the acromioclavicular ligament does not affect the relationship between the clavicle and the acromion to a great extent, permitting only an incomplete dislocation. The complete separation of the clavicle from the acromion is only possible when the trapezoid and the conoid ligaments are disrupted.

For the purposes of the operation I intend to describe, there is another anatomic detail that must be clearly explained. The span between the acromion and the coracoid process is occupied by a fibrous band, improperly called the coraco-acromial ligament. As a matter of fact, it is only a philogenetic vestige of a bone that exists in some inferior mammals. The coraco-ligament is of triangular shape, and is formed of three distinct parts. By its apex, the coraco-acromial ligament is attached underneath the acromion immediately outside of the acromioclavicular joint, extending its attachment from the border of the joint to the external border of this process. This detail is very important and should be kept in mind, since, by understanding this, the surgeon may provide a longer ligament for transplantation by making the correct incision as close as possible to the outer border of the acromion. The base of the coraco-acromial ligament is attached by two distinct strong bands, one anterior and one posterior, upon the coracoid process. The anterior portion is attached at the extremity of the coracoid process and the posterior one at its convexity, at the point usually called the angle of the acromion. Between these two thick fibrous bands of attachment lies the third part of the ligament, a loose connective tissue permitting the expansion of the subdeltoid bursa, the passage of blood vessels and also of the tendon of the pectoralis minor when this muscle does not take insertion on the coracoid process.

FUNCTION AND PHYSIOPATHOLOGY OF THE ACROMIOCLAVICULAR JOINT

The acromioclavicular joint, small as it may appear anatomically, has undoubtedly great importance in certain movements of the shoulder, specially in the circumduction of the shoulder girdle. It is impressive to see, through the fluoroscope, the amount of motion that this joint has to have during such circumduction. Ankylosis of this joint therefore results in extensive disability of the shoulder.

What happens when the acromioclavicular joint is forced beyond the limits of its normal range of motion? When the shoulder is projected backward, the acromion slides very little because the capsule and the acromion clavicular ligament are immediately put under tension, and the joint has a slight tendency to open. The clavicle follows to a certain extent this backward movement, but it is stopped by the tension of the trapezoid ligament. Exactly the opposite occurs when the shoulder is forced forward. The acromion slides, the acromioclavicular joint has a tendency to close

and the conoid ligament, under tension, stops the forward movement of the clavicle. When the shoulder is forced upward with

sule of the acromioclavicular joint and the acromioclavicular ligament are the first to give way; this constitutes the mechanism
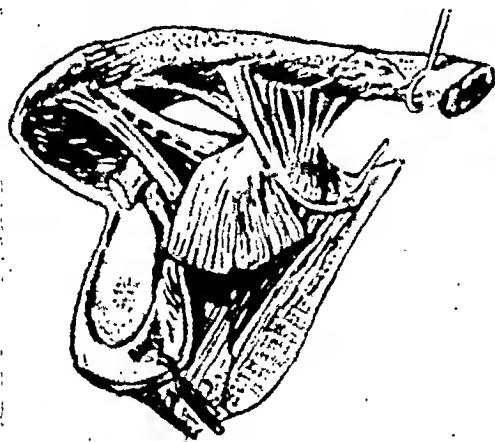
FIG. 1. Anatomic drawing showing coraco-acromial ligament with its three parts. Dotted line shows direction of the incision. (After Testut.)
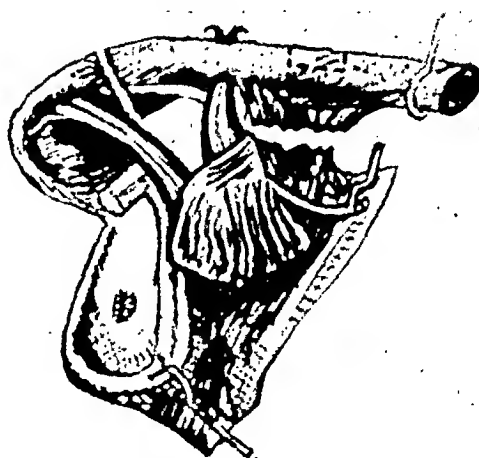
FIG. 2. Rupture of conoid and trapezoid ligament, tearing of capsule of acromio-clavicular joint. The posterior part of the coracoacromial ligament was incised and implanted into the clavicle through a drill hole.
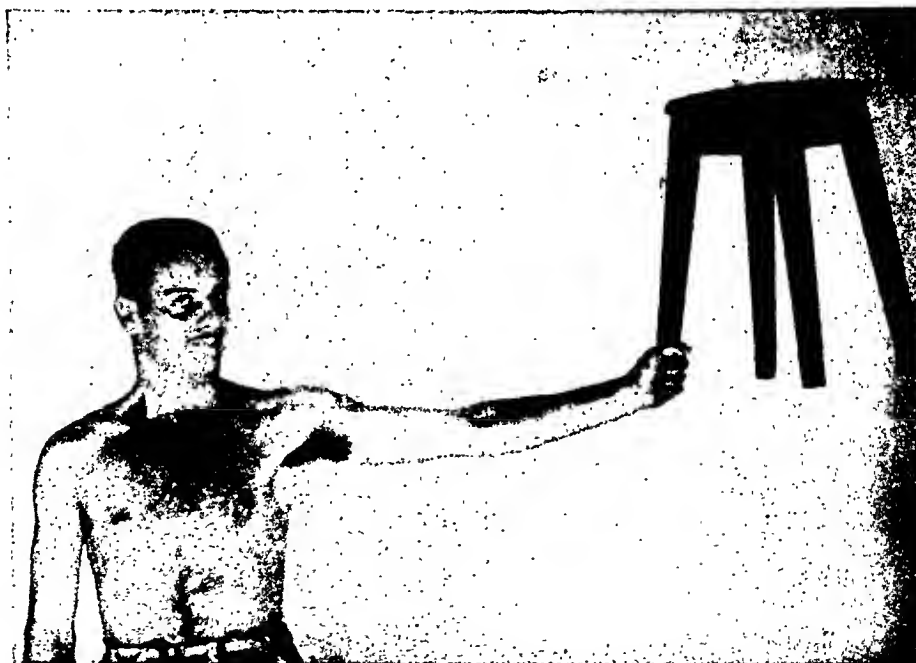
FIG. 3. End result in Case P. G., 28 years old. Complete acromioclavicular dislocation. One year after operation. Patient had been unable to lift the arm, and is now a jiu-jitsu wrestler in the police department of Rio. He can easily lift very heavy weights.

the arm in full extension, the conoid liga-ment is the first to resist.

In cases of severe trauma, when the limits of resistance are overcome, the cap-

of the incomplete dislocation. If the trauma is powerful enough to continue its action after the capsule and the acromioclavicular ligament have given way, then first the

trapezoid and later the conoid break, or vice versa, depending upon the direction of the traumatic force. When the traumatic

this ligament can be incised on the cadaver without any change in the relationship of the scapulohumeral joint. I have used

FIG. 4. A. F., before operation. Complete separation of outer extremity of clavicle which was entirely loose and almost protruding through the skin.

agent forces the extension of the upper extremity, the conoid is the first ligament to break, because it is the first to resist.

FUNCTION OF THE CORACO-ACROMIAL LIGAMENT

The coraco-acromial ligament is considered by some authors as a sling above the head of the humerus to protect its upward displacement, and by others as an enlargement of the glenoid cavity to form some sort of a "socket" for the head of the humerus. However, I do not believe that this anatomic philogenetic vestige (or any other of the same category), has any function. Cadenat proved experimentally that

both parts of the coraco-acromial ligament in performing the ligamentopexy of the dislocated acromioclavicular joint without any harm to the scapulohumeral joint. We all know that the upward displacement of the head of the humerus which is occasionally observed is always accompanied by fracture of the bony vault formed by the acromion and the outer third of the clavicle. The posterior part of the coraco-acromial ligament was first used by Cadenat to repair the displaced acromioclavicular joint. Cadenat, however, uses only the posterior part of the ligament. I believe I was the first to use the entire ligament, which is possible only if my modification of Cadenat's technique is used.

DIAGNOSIS AND TREATMENT

The diagnosis of acromioclavicular dislocation is a simple problem. Differentiation

avoided. The end results are always very poor.

The reconstruction of the ruptured
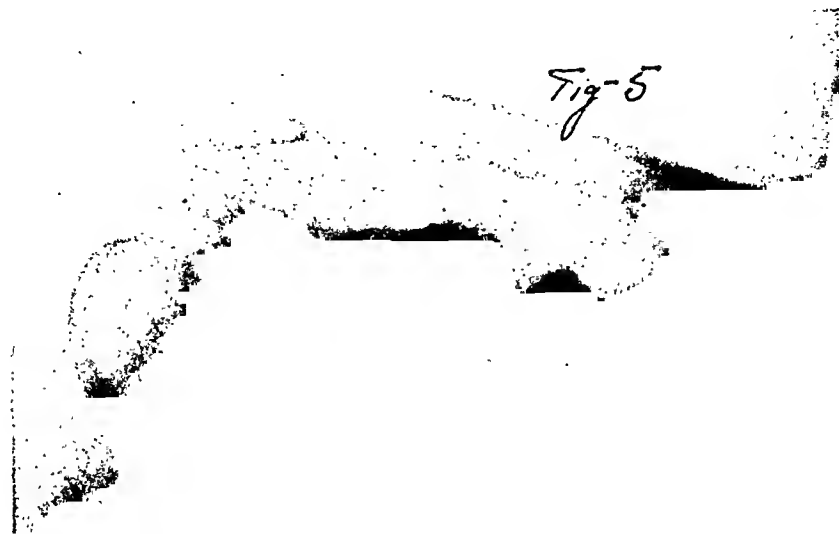
FIG. 5. A. F., one month after the cast was removed. The patient had full range of motion, being able to return to his heavy work of truck driver's helper. Perfect result, with 100 per cent restoration of the anatomic form.

of complete from incomplete dislocations is very important, however, as far as treatment is concerned. Not all writers who discuss treatment have been careful enough to mention the type of dislocation involved. One reads of a series of very good results obtained by conservative methods, but the kind of injury is very frequently unnoted. The incomplete dislocation, the one most frequently observed, is not at all serious. Conservative treatment invariably produces very good results. I, personally, believe that even without treatment complete restoration of shoulder motion would result, providing the real ligaments of the acromioclavicular joint, the trapezoid and the conoid, are intact. When the dislocation is complete, however, conservative methods never give good results; to attempt treatment by this means is only a waste of time.

Many operations have been designed for the treatment of acromioclavicular dislocation, but it is essential to note that any procedure employing wires, or any other method likely to cause ankylosis of the acromioclavicular joint, is to be entirely

conoid and trapezoid ligaments with living fascia lata may give very satisfactory results, but this requires two incisions instead of one, and is a much more complicated procedure. The importance of making only one incision through a small approach becomes even greater in compensation cases and in females. The operation that really can be considered on an anatomic basis is that first described by Cadenat, in which the coraco-acromial ligament is used. Cadenat's technique consists of incising the posterior portion of the coraco-acromial arch, and fastening it to the periosteum of the upper surface of the clavicle after it has been drawn behind the posterior border of the clavicle through the fibers of the trapezius.

When, in 1929, I saw Cadenat's operation for the first time, I noticed that the surgeon had great difficulties with the posterior part of the coraco-acromial ligament, which was entirely too short to go around the external third of the clavicle. The suture of the ligament to the periosteum of the clavicle is not at all dependable. In fact, the end result in this case was

very poor. I thought then that it would be much easier to drill a hole through the external third of the clavicle and implant the coraco-acromial ligament. I tried this maneuver on the cadaver, and found that the ligament, after it has been threaded through the drill hole, protrudes more than a half inch above the upper surface of the clavicle. That same year, my modification was tried for the first time on a living subject, with an excellent result. Since then it has been used in six other cases, with equally good results.

TECHNIQUE

The technique consists of:

1. A skin incision of 8 or 10 cm. is made, beginning slightly above the clavicle and running downward between the coracoid process and the acromion.

2. The deltoid is dissected and a short lateral incision is made at right angles to its fibers, if necessary. The coraco-acromial ligament appears then as a tight band between the coracoid and the inferior surface of the acromion. A piece of gauze in a Kocher is of great help in cleansing the whole extent of this arch.

3. With a thin knife the posterior part of the coraco-acromial ligament is incised, or both the posterior and the anterior parts are incised, as close as possible to the outer border of the acromion. The ligament is freed through its entire length to its inferior attachment, and a silk guide suture is placed at its freed superior extremity.

4. A hole is drilled through the outer third of the clavicle in line with the coracoid at the point where the clavicle and the coracoid are the closest together.

5. The dislocation is reduced and the ligament threaded through the hole from below upward, fastened to the periosteum and locked with a chip of bone.

6. Careful suture of the acromioclavicular capsule and soft parts above the joint is performed.

7. Suture of the deltoid and suture of the skin follow.

8. Plaster cast is worn for four weeks.
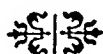
TREATMENT OF SUBDELTOID BURSITIS

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IN a discussion of treatment of stiff shoulders, it is necessary to have first a clear conception of the pathologic process that causes this stiffness. If we eliminate tuberculosis, sepsis and fractures about the shoulder joint, we have a large group of cases in which the subdeltoid bursa is involved and, by common usage, the condition is called subdeltoid bursitis. This discussion will be confined to the latter group.

At the risk of being too elemental, let me review the anatomy of the shoulder joint, or at least the essential points that have to do with bursitis. Practically all stiff and painful shoulders are limited in motion in two directions, abduction and rotation. Anteroposterior motions, which are joint motions only, are not restricted. In tuberculosis or septic arthritis of the joint proper, all motions are restricted. The articular surface of the head of the humerus and the glenoid are not involved, so that we have a different situation from that in other joints.

The two muscles that are essentially involved in abduction of the arm are the deltoid and the supraspinatus. The supraspinatus arises from the scapula and when it passes under the olecranon process it spreads out and becomes a part of the capsule of the joint. With the joint capsule, it is attached to the greater tuberosity or the sulcus just at the top of the tuberosity and the edge of the articular surface of the humerus. Lying over the capsule of the joint and the supraspinatus muscle is the free space that is called the subdeltoid bursa, extending about 2 inches over the surface of the joint. Then over this lies the deltoid muscle. It seems to me that these anatomic facts are necessary in understanding the treatment of bursitis, although it does not cover all the anatomy.

In 1934, I published[1] an analysis of the clinical facts on subdeltoid bursitis. One of the chief points was that the patients could be divided into three different groups, rather distinct clinical groups (Table 1), and the only point in common was that they would end up in the same condition as an end result, namely with a stiff and painful shoulder with loss of abduction and rotation. When we talk about treatment for bursitis we must know what group we are talking about and what stage of the condition we are treating. It is foolish to say that all bursitis should be treated by one method.

TABLE 1
ANALYSIS OF 100 CASES OF SUBDELTOID BURSITIS

Acute Fulminating	Chronic Adhesive	Traumatic
29 cases	46 cases	25 cases
Average age—48	Average age—56	Average age—55
9 cases 30–40	2 cases 30–40	1 case 30–40

These three clinical groups are: (1) the acute type which comes on rather suddenly; (2) the chronic adhesive type with slow onset, the so-called "periarthritis" of the shoulder or the "frozen shoulder," which may end in an absolute loss of abduction and rotation; and (3) the traumatic type, which has a history of slight trauma as a cause.

In the acute type, it is rather interesting to observe that these are the cases that show the calcification that is supposed to be in the bursa. It is now known and has been proved many times that this calcification is in or on the tendon of the supraspinatus

and not in the bursa. The chemistry of this calcification, whether chronic or acute, is calcium carbonate. In the acute stage it is a

Fig. 1. X-rays taken three days after onset, showing calcification.

liquid, gelatinous substance and when the bursa is opened and drained it looks like thick creamy pus. In the chronic stage it is granular and is often infiltrated through the supraspinatus. These facts have been proved by operation, personally and from literature.

The adhesive type, often called periarthritis, generally has a slow onset, and the loss of motion in the course of weeks becomes more evident, until in some cases there may be absolute loss of abduction and rotation.

The traumatic type gives a history of some form of strain as a cause. The type of injury is often trivial, a sudden wrench, such as stepping off a train and hanging by one arm, a muscle pull. We see the same condition following a Colles' fracture, a stiff and painful shoulder resulting. If an x-ray is taken and is negative for fracture, the injury is passed as a strain. A few weeks later, however, it is discovered that the patient cannot raise his arm and we have what is called traumatic bursitis.

The pathology of the traumatic bursitis is essentially a tear of the capsule of the joint at its attachment to the humerus, at that point where the supraspinatus becomes a part of the capsule of the joint. The tear is never in the belly of the muscle, but if it is of any extent and has been

present for some time, the upper part of the tear is well retracted under the acromion process. My premise is that traumatic

Fig. 2. Six weeks later, showing disappearance of calcification.

bursitis and rupture of the supraspinatus are pathologically the same thing, only differing in the extent of the rupture, this causing the difference in symptoms.

Now let us consider the treatment in the acute stage of the first group. These are the cases that come on fairly rapidly with very acute pain on any movement of the arm, pain especially at night. If an x-ray is taken it will probably show a shadow of calcification which is often reported as in the bursa. This is the type of case that does so well if an incision is made extending from the acromion process, splitting the deltoid and coming down on the white mass on top of the capsule and supraspinatus. If this is incised in the acute stage, a soft substance, rather like thick, creamy pus, is found. There is definite relief from this procedure and it is occasionally indicated.

On the other hand, there is plenty of evidence that this shadow may be present in the acute stage and entirely absent three weeks later. The following case illustrates this point: Mrs. D. (Figs. 1 and 2) had an operation for simple appendectomy and during the last part of her hospital stay she developed an acute bursitis which showed a large shadow of calcification. She was treated conservatively, with heat and morphia during the acute stage, followed by careful physiotherapy to regain motion.

X-rays taken six weeks later showed a disappearance of the shadow.

I have observed this disappearance of

Fig. 3. Anatomy of ruptured supraspinatus.

shadow in several cases. The question of operation is therefore a matter of choice and depends on whether it will relieve an acute situation. I do not believe it can be said that operation is indicated in every case, although I do believe it should be used more freely. As I look back on the history of cases that were acute and then have become chronic, I often wonder whether more intensive treatment at first would not prevent the long after-care of a chronic case.

What position should we take in regard to patients who show calcification, with symptoms which have persisted for quite a period of time, and where definite symptoms of pain on motion and some restriction of motion are present? By x-ray it looks as if you could cut down on the mass and remove it like a foreign body. However, on cutting down on the supraspinatus, this mass will be found to be granular and rather incorporated in the tendon so that it cannot be removed except by curette. Sometimes this has to be done, but the convalescence is slow, and it takes a lot of physiotherapy to restore motion. I believe we ought to be very slow in deciding to operate. In a recent patient, operated upon because there was a definite block and catch due to the calcification, the tendon proved to be infiltrated, and I am doubtful

whether I have improved the condition immediately. I believe it is better not to consider the calcification as the important
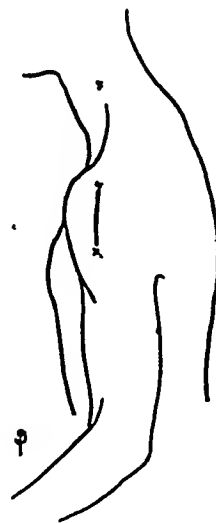
Fig. 4. Incision for operation.

factor, but to treat as one would a case which showed adhesions.

The most troublesome type of stiff shoulder that I have to deal with is the chronic adhesive variety and this group is the largest in my series of shoulder cases. Some of the cases in this group may start as acute calcifications; some undoubtedly come from the third (traumatic) group, and when they present themselves for treatment they are, practically, cases of chronic adhesive bursitis. But there is a large group in which the condition comes on evidently without known cause, develops slowly and ends up in a shoulder joint without any motion in abduction and rotation. These are the cases that have been called "periarthritis" of the shoulder, indicating an infectious process. I believe there is very good evidence that the pathologic picture is one of adhesions within the bursal walls, varying from slight to absolute tying up of the bursa.

Here again it is desirable to vary the plan of treatment for cases of the early stage and for those where there is an absolute loss of motion. I am sure that if we see one of these cases fairly early, recognize

that without treatment complete loss of abduction may result, and can make the diagnosis and prognosis so definite to the patient that he will follow treatment, we can prevent the complete tying up of the shoulder. Patients who come from a distance often give a history of a mild complaint at first, a study for focal infection, an indefinite outline of treatment and a common diagnosis of neuritis.

For a patient seen in the early stages, I first outline the exact loss of motion in degrees, then start on a definite régime of so-called physiotherapy. This means, not giving up control to a physiotherapist and this failing, turning to other measures, but keeping absolute control all the while. This will test all one's patience and will bring out all the knowledge of care of a joint. First, some form of heat is advisable, diathermy, baking or hot fomentations; second, gradual stretching under guidance is inaugurated; third, exercises are given up to the point of causing more reaction.

The same process should be undertaken in the chronic form, because sometimes it is possible to find the adhesions beginning to give under so-called conservative treatment, and if that is so I am sure that it is better to get it gradually. Within two weeks it can be estimated whether this type of treatment will accomplish anything. Then, if there is no give, and any attempt at motion is painful, I advocate the hospitalization of the patient and the breaking up of adhesions under anesthesia.

The technique of this manipulation is as follows: with good preliminary medication and gas-oxygen sufficient to get complete relaxation, the whole upper arm is firmly held with one hand and the shoulder with the other. The arm is brought out in abduction, and at a certain stage there is a definite snap, which means the breaking of adhesions. This allows the arm to go up into complete abduction, and it is rotated to complete all motions. Then the arm is held in an abduction splint, and motions and physiotherapy are started as soon as the immediate reaction subsides.

The result of manipulation seems to depend somewhat on the condition of the adhesions. If these are firm, sometimes
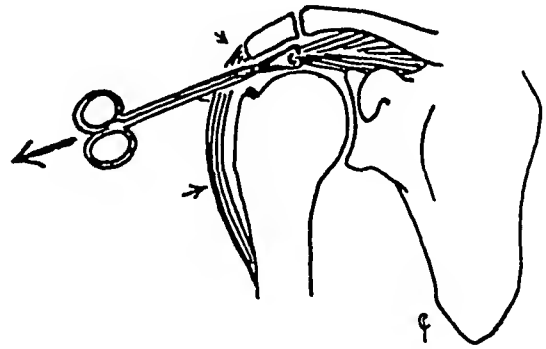
Fig. 5. Diagram of method of reaching the supraspinatus.

described as "ripe," if they break with a snap, there is a smoother convalescence. In any case careful follow-up is necessary.

The danger of careless manipulation is the possibility of a spiral fracture of the humerus. It should not occur if proper methods are used. Proper manipulation shortens the length of convalescence in certain cases, especially in those that are resistant to gradual stretching.

This brings us to the discussion of the treatment of traumatic bursitis, tear of the capsule and rupture of the supraspinatus, which I consider the same condition but of varying degree.

There is a rather definite test that will generally distinguish between adhesions and a ruptured capsule, although the latter, being so closely anatomically connected, has a definite effect on the bursa. In all cases the loss of motion is in abduction and rotation. Active abduction is restricted and in the sitting position passive abduction is limited. When the patient lies down, if the limitation is due to adhesions, there is still loss of abduction, but if it is due to a rupture of the capsule, it is often possible to abduct the arm. The secret of this test is that in the recumbent position the function of the supraspinatus is taken up by the examiner, and also the thickening of tissues around the tear roll up under the acromion process.

The important part of the treatment is to recognize that there is a tear of the capsule or supraspinatus. (Fig. 3.) If this is recognized as a possibility then the first step is to put the arm into an abduction splint as early as possible. I have had the opportunity to operate on an early case (within four days) and at the attachment of the capsule there was definite evidence of hemorrhage into the tissues without the pulling up of the supraspinatus under the acromion. There was no wide separation of tissue. I could well imagine that, if the arm had been put into abduction and kept there for two weeks, the tendon might have healed without operation. Undoubtedly this happens in the minor cases but there is a thickening of tissues in this area that tends to block abduction. At the end of two or three weeks it is usually possible to say whether conservative treatment will accomplish a good result. If there is no return of function of the supraspinatus then operation is definitely indicated.

The technique of the operation I have been using follows (Fig. 4):

A straight incision of about 2 inches is made from the acromion process downward. The deltoid muscle is split and not cut; with the use of narrow retractors the lower attachment of the capsule is seen. By rotating the arm, the extent of the tear can be seen. By pulling down on the arm the head of the humerus is separated from the acromion process. At this point a search is made for the retracted portion of the capsule and supraspinatus. It can be seen under the acromion process and with Kocher forceps can be pulled down. (Fig. 5.) Except in very old cases I do not believe it is necessary to cut the acromion process with an osteotome to get more exposure, but one should be ready to do so. This procedure adds to the operation and lengthens the convalescence. A mattress suture of silk is placed in the capsule and the tendon is sewed to the tissue above the process. Interrupted catgut is used for the split deltoid and the skin is sutured. All

this time the arm is held in abduction until the splint is applied.

The arm is kept in an abduction splint for three weeks. It is advisable to remove the splint and have passive exercise, but always with the arm at right angles in order not to strain the sutures. In about three weeks the arm can be let down, and exercises to develop the power of abduction are used. In six weeks the result should be a return of power of abduction with fairly normal motions of the shoulder joint.

It has been suggested that this technique does not give a complete exposure to the shoulder girdle. This is true, but on the other hand a large exposure through the olecranon requires much longer fixation, and so far I have been able to reach the supraspinatus and suture it without much disturbance to the shoulder girdle. It makes for a quicker convalescence.

SUMMARY

It is first necessary to differentiate the types of subdeltoid bursitis because the treatment varies according to the pathology.

The acute cases with calcification usually can be treated conservatively, by rest, heat and narcotics with a reasonable chance that the calcification will disappear spontaneously. Surgical drainage gives immediate relief in the acute cases. It is in this stage that the technique of insertion of needles and washing with saline solution is of benefit.

If the calcification persists, as shown by x-ray, the problem is whether there is enough mechanical block to warrant curettage of the calcification or whether it should be treated by physiotherapy for the adhesions that have taken place. The drainage of the acute calcification is easy, while the removal of an old calcification is not so satisfactory, although occasionally indicated.

The treatment of the adhesive type of subdeltoid bursitis in the early stages is intense physiotherapy and generally the

complete adhesions with total loss of abduction and rotation can be prevented. When the adhesions are very definite and do not respond to conservative treatment, it is a waste of time to continue too long. Manipulation is then indicated.

In the traumatic type, the milder cases respond to abduction fixation, and gradual restoration of function. Whenever the active power of abduction is lost, indicating the loss of function of the supraspinatus, then operative work and the suture of the muscle and tendon are definitely indicated.

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1. ROGERS, M. H. A study of 100 cases of subdeltoid bursitis. *J. Bone & Joint Surg.*, 16: 145 (Jan.) 1934.
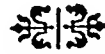
SUBCUTANEOUS rupture of a vein is commonly seen in association with fractures, dislocations and severe contusions, while varicose veins may rupture subcutaneously from quite trivial blows.

THE TRAUMATIC SHOULDER

WITH SPECIAL REFERENCE TO RUPTURE OF THE SUPRASPINATUS TENDON

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IT is encouraging to see more thought given the shoulder joint and it must be a source of no little satisfaction to Dr. E. A. Codman[1] that his "orphan joint" is being rescued from neglect by the noteworthy articles on the ruptured supraspinatus tendon which are appearing so frequently in the literature. Philip D. Wilson,[2] E. L. Keyes,[3] E. B. Fowler,[4] Davis and Sullivan[5] have contributed commendably to the subject. The scope of this article is to relate our experience with supraspinatus pathology and to comment upon the various lesions leading to shoulder disability due to injury.

Reviewing my files, I have chosen a five-year period following January 1, 1933 and include in this group only the recorded shoulder injuries.

TABLE I

A. Contusions and abrasions of shoulder....		681
B. Lacerations of shoulder.................		14
C. Sprains of shoulder....................		189
D. Injury to clavicle		
1. Fractures at outer third...........	49	
2. Dislocation at acromioclavicular joint.........................	29	
3. Dislocation at sternoclavicular joint	5	83
E. Dislocation of humerus.................		49
F. Fractures of humerus		
1. Surgical neck, anatomic neck and greater tuberosity...............	93	
2. Fracture-dislocation...............	6	99
G. Injury to scapula		
1. Fracture of acromion.............	5	
2. Fracture of spinous process.........	6	
3. Fracture of body..................	11	
4. Fracture of glenoid process.........	1	23
H. Subacromial bursitis...................		17
I. Synovitis.............................		4
J. Burns about the shoulder..............		5
K. Arthritis of shoulder		
1. Traumatic.......................	3	
2. Chronic.........................	19	22
L. Supraspinatus rupture.................		24
M. Infraspinatus rupture.................		1
N. Tenosynovitis long biceps tendon........		3
O. Rupture long biceps tendon.............		2
Total...........................		1216

ACROMIOCLAVICULAR DISLOCATION

Acromioclavicular separation or dislocation occurred in 2.5 per cent in the series—six times as common as dislocation at the sternal end. Radiography is essential to exclude chipping proximal to the articulation, which may have a bearing on the treatment. Supportive or conservative treatment is advised. We believe that operative treatment, with but few exceptions, should be done only as a last resort, as operative results have not proved uniformly satisfactory.

Our best results have been by conservative external support—counterpressure between the elbow and the outer end of the clavicle. The method is really immaterial provided that the parts are completely, firmly and continuously maintained day and night for five weeks, followed by the use of a sling to counteract the weight of the arm for at least two weeks.

The successful operative treatment must include adequate security for the acromioclavicular elements in addition to the coracoid and trapezoid ligaments which bind the outer end of the clavicle to the coracoid process. I recently removed a steel pin which had been driven through the tip of the acromion (unfortunately missing the shaft of the clavicle) which showed sufficient bone absorption to discourage following the procedure. A good sized tibial transplant is preferable to wiring and the mere drilling and securing with kangaroo tendon or heavy chromic has such a high degree of recurrence as to cause consideration of discarding the procedure. One may

freshen, but not curette the joint surfaces. Many failures occur from too early mobilization. The weight of the arm should be

5. Test for supraspinatus rupture
6. X-ray recheck
7. Sling, ten days

FIG. 1. Right shoulder: shows "cupping" at insertion of supraspinatus tendon due to bone absorption following avulsion, as confirmed by operation.

FIG. 2. Left shoulder: normal.

supported for at least eight weeks after operation.

ACUTE SCAPULOHUMERAL DISLOCATION

The etiology and type are of less interest than the treatment. Treatment should never be undertaken without prereductional radiography. It is imperative to know whether the dislocation is complicated by an incomplete or a complete nondisplaced fracture at the humeral neck. Strictly against orders, the house staff on two occasions in this series reduced the shaft into the glenoid cavity, leaving the unreduced head behind in the axilla—results, one "frozen" shoulder and one patient with a two-thirds schedule loss! In the case of night admissions to the hospital it is wiser to leave the dislocation unreduced until x-ray can be done.

Treatment routine is as follows:

1. Morphine
2. X-ray to exclude complicating neck fractures
3. Gas anesthesia
4. 45 degree counteraxillary traction reduction

8. Gentle manipulation and physiotherapy three weeks
9. Caution patient against recurrence.

Dislocations are emergency cases. Morphine and pre- and post-reduction x-rays are routine. As to method, the unbooted heel in the axilla has, like castor oil, stood the test of time and should always be preferred to the Kocher method.

In the former procedure, the right foot should be used for the right arm, and vice versa. The operator should be seated on a stool at least 12 inches below the level of the operating table so that traction can be made 30 degrees posteriorly and 45 degrees in abduction (the reverse mechanism for the most common subcoracoid dislocation). If traction alone at this angle is not sufficient to cause the arm to snap back, the arm should be (1) slightly—very slightly—rotated, and (2) pried—very slightly—over the operator's instep with (3) the assistant pressing on the head. Failure may result from incomplete anesthesia with muscle spasm. All forces should be gradual with due protection to the brachial plexus. Traction alone at the proper angle should be employed when fracture complicates the picture. With failure after the second attempt, try the Kocher method.

In the Kocher method, the arm is subjected to such dangerous tortion, if not properly applied, the fracture may result

Fig. 3. Right shoulder: "cupping" and bone absorption at supraspinatus insertion.

in susceptible ages, with comparatively little force. Reduce in the following order:

1. Hold the flexed elbow firmly against flank.

2. Rotate arm externally until forearm is 90 degrees with body.

3. Raise elbow and slightly move it toward midline.

4. Then rotate arm inward, keeping elbow slightly raised.

5. After reduction, allow patient to come out of gas.

6. Test for supraspinatus integrity.

7. Apply sling or velpeau.

CHRONIC SCAPULOHUMERAL DISLOCATION

Since the advent of the Nicola[6] procedure, shoulder disability from repeated dislocation has been shorn of its terror. We have abandoned other methods of repair in its favor and feel that a distinct forward step and a long looked for answer to the problem has been made by this operation. In seventeen operative cases, we have had but one recurrence. In this case there was predisposition to recurrence as the inferior rim of the glenoid had been fractured, or perhaps "worn down" by its daily habit. Witnessing reoperation, there was an elongation or overstretching of the supracapital portion of the biceps tendon which could have occurred when the patient was

removed from the table after his first operation, his shoulder being permitted to droop downward while he was still under

Fig. 4. Left shoulder: normal.

anesthesia. We have since corrected this possibility by securing the shoulder with a firm velpeau for at least twenty-four hours after operation, until the reactionary muscle spasm will have immobilized it. The operative procedure is simple and effective. Briefly, the steps are as follows:

1. Make a 3 inch incision at the pectoralis-deltoid junction.

2. Isolate the subjacent biceps tendon above the tenuous pectoralis tendon.

3. Ligate the biceps tendon at a $\frac{1}{4}$ inch interval with silk, leaving ends long.

4. Divide the tendon between ligatures.

5. Incise the bicipital fascia, releasing tendon.

6. Depress arm to expose humeral head, dislocating it into the wound.

7. Drill a $\frac{3}{8}$ inch hole beginning near center of head downward and forward terminating just below the bicipital groove.

8. Draw ligature and proximal tendon end through hole.

9. Repair capsule and bicipital fascia.

10. Secure tendon ends by overlapping above ligatures.

11. Repair wound and apply a firm velpeau bandage.

FRACTURE-DISLOCATION

Fracture-dislocations may be primary or secondary. The lesion is, of course, caused primarily by the continuation of the same force which produced the dislocation or

secondarily by (1) neglect to detect an incomplete or non-displaced complete fracture at the neck radiographically before reduction was attempted; or (2) by excessive torsion in the Kocher application where preëxisting fracture was not present.

When the shaft is unfortunately reduced into the glenoid cavity, leaving the head remaining subcoracoid or in the axilla, immediate open reduction is indicated. Delay is disastrous as the cancellous head becomes more spongy and fragmentation may lead to ankylosis. In the early cases, the shaft may frequently be steepled and impacted into the head. Strict conservatism should prevail in late cases if there be reasonable motion. Hamlet's dictum of "Bearing those ills we have" should be honored.

FRACTURES AT THE HUMERAL HEAD AND NECK AND THE GREATER TUBEROSITY

Surgical neck fractures rarely come to open procedure. Immobilization at 90 or 30 degree angles has its separate advantages. Excessive abduction often leads to angulation from acromial impingement and should be watched radiographically. Rare neck cases may require steepling into the head.

Anatomic neck fractures, usually in the sixth and seventh decades, impacted, require but simple and comfortable immobilizing methods.

Greater tuberosity fractures frequently complicate dislocation. The tuberosity "takes care of itself" when the dislocation is reduced. We are assured of supraspinatus tendon integrity when the greater tuberosity is fractured. Small non-displaced tuberosity fractures give a surprisingly similar symptomatology to the spinatus lesion. Longer immobilization is usually required when this tendon anchorage is involved.

SYNOVITIS AND BURSITIS

It is obvious that in every traumatic intra-articular lesion there is a hemorrhagic or serous effusion of varying degree, but it is surprising that the shoulder furnishes so few cases of acute effusion in comparison with the knee. The fact that the synovial membrane of the shoulder joint is much more muscularly protected than that of the knee, probably accounts for the very low incidence of only four recorded cases (not complicated by dislocation or fracture) in 1,216 shoulder injuries. Slight effusion might readily be overlooked.

The diagnosis of "burstitis" is so frequently the refuge "to satisfy the patient" that we would refrain from its discussion. We believe that there are very few actual traumatic effusions into the shoulder bursae —far less than into those about the knee. Making due allowances for the individual coefficient of error, we have been satisfied with the diagnosis in but three instances (cf. Table 1) of acute traumatic bursae— chronic, calcified, yes, plenty—but not traumatic, though many are made painful by bruising.

SUPRASPINATUS RUPTURE

Industry has called our attention to disabled shoulders. Insurance company statisticians forced our shortcomings and only of recent years have we become shoulder-conscious. I refrain from thinking how many tendon cases I thought were bursitis, periarthritis, arthritis, myositis, sprains, and what not. However, we must be as cautious in letting the pendulum swing too far in the opposite direction.

One is interested in the observation of Philip D. Wilson that "in his sixteen years (1931) of orthopedic surgery, he only made the diagnosis twice, and that in the next eighteen months, ten cases were diagnosed, seven of which submitted to operation."

Incidence. Twenty-four or 1.9 per cent supraspinatus cases are sufficiently common for diagnosis and treatment as a definite surgical entity. Without operation the average case represents a schedule defect of from 60 to 80 per cent arm function ($1,500 to $5,000 reserve per compensation case depending upon the rate—New

York State). By operation, the economic saving is incalculable and the patient restored to industry—improved or cured.

Etiology. Sex: In our twenty-four cases, there were twenty men and four women— the ratio being six to one. The male preponderance is naturally due to industrial exposure.

Age: between 25 and 62 for male and female. For females, between 28 and 53; and for males, between 25 and 68. The average age for females was 45, and for males, 46.4 years. The average for the whole group is 46.1 years.

Predisposing: The lesion occurs chiefly in the fifth and sixth decades when degenerative joint and tendon changes are common. We feel, therefore, that most of the tendon lesions caused by indirect and many by direct violence are favored by preëxisting pathologic anchorages.

Mechanism. In many cases the mechanism of rupture is difficult to determine, particularly in those cases in which indirect violence is involved. Many intelligent patients cannot tell "just how" they fell. Violence is as quick as thought. Many tendons rupture "before the fall." In any event, some sudden, powerful interruption in the abduction force or direct impact is essential.

Our series shows rupture was sustained by muscular action when the arm was being lifted in abduction (three cases) or by direct point violence (21 cases). Those injured by direct muscle strain were caused by: (1) being jerked by a hoisting crane with arm extended; (2) falling and hanging on with the arm to a girder; and (3) reaching to place a heavy box on a high shelf. Those dealing with direct point violence have, in concensus, a history (1) of falling directly on the shoulder or (2) having a heavy object strike the shoulder.

It is interesting to quote some of Codman's records as to the histories of indirect violence—"tossing a heavy blanket over a clothes line—sudden pain; tightening a saddle—felt something give; pulling a heavy case along the floor with a hook—snap

and pain; bar slipped while pushing a freight car—shoulder wrenched; catching a 100 pound sack of beans unattended— pain and snap; backfire while cranking a car—sharp pain; swinging a board—pain; wheeling a barrow, fell forward into barrow with hands on handles; fell with arm in abduction, etc., etc." Wilson relates "folding a heavy blanket at arm's length; throwing a stone, and so forth." Davis and Sullivan relate, "loading a case of milk bottles." The variety of causes due to indirect violence merely indicates too sudden strain or inertia in raising the arm much in principle of the snap of tow rope when the towing automobile "gives her too much gas."

The mechanics of the injury, therefore, are that "either in falling, the patient suddenly abducts the arm from the side in order to break the fall, the rupture occurring during this movement before the shoulder strikes the ground, or the fall or blow is received on the back of the shoulder with the production of a momentary forward displacement of the head of the humerus during which the tendon ruptures, followed by immediate spontaneous replacement of the head so that no demonstrable dislocation results." Anterior dislocation of the shoulder is certainly capable of causing rupture of the supraspinatus tendon. One case some years ago, which we distinctly recall (one which, unfortunately, we have been unable to follow up recently) was a middle aged man for whom we reduced a subglenoid dislocation. We were not able to explain then, why, following his convalescent period, he was unable to abduct the arm beyond the horizontal line. We are sure that this is one of the cases in which we had failed to recognize the essential postreduction pathology.

Anatomy. The shoulder joint is classified, in general, as diarthrodial. The constituent parts of joints of this class are: (1) two or more bones, each covered by articular hyaline cartilage; (2) A fibrous capsule uniting the bones; and (3) a

synovial membrane which lines the fibrous capsule. The diarthroses are divided into the homomorphic, in which the surfaces are equal and similar; and heteromorphic, or unequal and dissimilar. To the enarthrodial, or ball and socket group, belong the shoulder and hip joints, allowing the most freedom of movement.

The movements which may take place at a joint are: gliding, angular, rotatory or circumductory. Rotation and circumduction are found in the shoulder joint; the former is the revolution of the humerus about its own axis without much change of position; the latter is the movement compounded of all angular movements in succession by which the moving bone describes a cone, the proximal end of the cone forming the apex.

If an incision be made on the anterior aspect of the shoulder joint, extending down from the acromioclavicular joint for a distance of about 3 inches, we come upon the superficial fascia. The nerves which lie therein are derived from two sources: (1) the posterior supraclavicular nerves from the third and fourth cervical nerves which cross the lateral third of the clavicle and the insertion of the trapezius to overly the proximal half of the deltoid; and (2) the cutaneous branches of the axillary or circumflex nerves which are: (a) the lateral cutaneous nerve of the arm which winds around the posterior border of the deltoid muscle; and (b) several fine filaments which pierce the substance of the deltoid itself.

The next structure is the deep fascia, which is fairly strong and, as it passes from the deltoid to the muscles which spring from the lower part of the posterior aspect of the scapula, it becomes strong and dense over the infraspinatus, teres minor and teres major muscles. The deep fascia takes its attachment from the infraspinous fossa between the infraspinatus and teres major muscles and as it proceeds forward, it splits into two lamellae—a superficial and a deep, between which the deltoid muscle is enclosed.

After the deep fascia has been cut, the deltoid muscle composed of short, coarse fasciculi is exposed. It arises from the anterior border and adjacent part of the upper surface of the lateral third of the clavicle, from the lateral border of the acromion, and from the inferior lip of the posterior border of the spine of the scapula. The fasciculi converge rapidly as they pass distally to the pointed tendinous insertion on the rough deltoid tubercle situated in the middle of the anterolateral surface of the body of the humerus. The action of the deltoid is that of an abductor, and a medial and lateral rotator of the humerus.

It is well to remember that the deltoid covers the proximal part of the humerus, and develops the region of the shoulder joint behind, laterally and in front. It also covers the coracoid process of the scapula and is separated from the shoulder joint by the muscles which are attached to the proximal end of the humerus and by the subacromial bursa.

Having separated the fibers of the deltoid, we come upon the subacromial bursa, the largest bursa of the body, intervening between the acromion and the deltoid above, and the muscles which lie immediately upon the upper aspect of the capsule of the shoulder joint just below. The bursa facilitates the play of the proximal end of the humerus and the attached muscles on the under aspect of the acromion and deltoid. Perhaps we can stress this more by stating that the bursa is nearly always found between the acromion and the coracoacromial ligament above and the supraspinatus muscle and capsule of the joint below.

After incising the subacromial bursa, the supra- and infraspinatus and the teres minor muscles are exposed, and beneath them the synovial capsule.

The supraspinatus muscle arises from the medial two-thirds of the supraspinous fossa. From the origin, the fibers converge and, proceeding under the acromion, end in a short, strong tendon which is inserted

into the uppermost of the three impressions on the greater tubercle of the humerus. The tendon is closely adherent to the capsule. The infraspinatus tendon, likewise, is adjacent to the capsule as it attaches to the middle impression on the greater tuberosity. The teres minor attaches to the lower or third impression of the greater tuberosity. All structures fuse and form a musculotendinous cuff.

The abductors of the arm are the deltoid and the supraspinatus. The movement of abduction has a most decided and definite resistance offered to it other than by muscles and ligaments, for the greater tuberosity of the humerus by striking against the acromion process and corocoacromial ligament stops short any further advance of the bone in this direction; thus, abduction ceases altogether as soon as the arm is arised to a right angle with the trunk. Further elevation beyond the right angle is effected by the rotation of the scapula around its own axis by the action of the trapezius and serratus anterior muscles upon the sternoclavicular and acromioclavicular joints, respectively.

The acromion and coracoid process, together with the coracoacromial ligament, form an arch, which is separated by a bursa and the tendon of the supraspinatus from the capsule of the shoulder. Beneath this arch the movements of the joint take place, and against it, the head and tuberosities are pressed when the weight of the trunk is supported by the arms; the greater tuberosity and the upper part of the shaft impinge upon it when abduction is carried to its fullest extent

If we remember these relations, we shall understand why rupture of the supraspinatus muscle prevents complete abduction.

Pathologic Action. Theoretically, rupture of the supraspinatus takes away the ability to abduct the arm from the side but ought not to interfere with the power of sustaining the arm in right angle abduction of the shoulder when it is passively placed in that position. This test is often positive in patients with complete rupture of the supraspinatus tendon but, when, as often happens, the tear is small, sufficient tendinous tissue is left intact to transmit a pull to the greater tuberosity and there is sufficient ability present to initiate abduction. This movement is weak, and the weakness can be easily demonstrated by a resistance test and by careful observation of the movements of the scapula during abduction in comparison with the normal shoulder. A different rhythm of motion can be seen. Furthermore, patients with a rupture of long duration learn to compensate for their weakness by using other muscles, in a "trick way."

Pathology. The pathology of the lesion is a rupture of the tendon which usually takes place in close proximity to the greater tuberosity. This is the site of the weakest link in the transmission of its power. Upon critical review of the anatomy again, we are surprised at the skeletal capacity of the supraspinatus fossa and the strong, thick tendon which passes beneath the acromion, just proximal to its fan-shaped attachment. The magnitude of the tendon, obscured beneath the acromion and the massiveness of the muscle belly concealed in the supraspinatus fossa is striking. But when the rounded tendon flattens into the fan-shaped arrangement at the facets, considerable loss in structure and strength ensues with concomitant predisposition to tear.

Following the rupture, the tendon retracts, enlarging the space between the ruptured ends. This creates an opening of greater or lesser extent through which there is a direct communication between the bursa and the shoulder joint. However, in most cases there is only a small tear which involves but a few fibers of the tendon. Codman considers this type of injury as the most common cause of traumatic subdeltoid bursitis. One should bear in mind that many of the calcified deposits that are diagnosed as subacromial bursitis are the results of intrabursal hemorrhages which have taken on calcific

degenerative deposits. Because of the proximity of the bursa and the supraspinatus tendon, many cases of bursitis are, we believe, the direct result of partial tendon tears and, conversely, many calcified bursae are attempted tendon repair processes.

The gap in the ruptured tendon varies from 1 to 2½ inches. The distal portion is usually frayed, and presents irregular margins at the rim. These margins are thickened and their borders usually show beginning calcium deposit, depending on the length of time elapsing from the time of accident to the time of operation. At times the capsule of the joint has been so rent as to expose the cartilage covering the head of the humerus. In two instances it was necessary to divide the capsule to show the lesion. Few cases show an avulsion of part of the greater tuberosity, similar to a sprain-fracture. In these instances a cupping effect seen radiographically is found.

Beyond the three month period adhesions set in, which get progressively worse as time goes on. These are the cases in which an exploratory arthrotomy and an attempt to repair will be of problematic benefit.

Wilson quotes Dr. Codman as stating that "in the pathologic study of 100 shoulders in fifty-two autopsy subjects, rupture of supraspinatus tendon was found in 39 per cent of the specimens and in twenty-one it was of such sufficient size as to expose the head of the humerus to view."

It maybe recalled that the coracoacromial ligament with the bursa and the tendon of the supraspinatus muscle form an arch between the acromion and coracoid processes. It is our belief that when the tendon is ruptured and the space has widened between the two ends, there is a loss to the fulcrum position of the greater tuberosity as it lies under the arch. As a result the 90 degree angle or abduction cannot be overcome actively, but this has to be done passively, because as the arm

is lifted at the distal end by the passive movement, the "catching" is released and the arm can be raised to that level.

Symptoms. 1. A critical history of the type of violence, either direct or indirect, as noted previously, is essential. The history of sudden onset is usually that of a painful snapping sensation in the region of the shoulder, followed by weakness in elevation. The failure to regain normal function upon reduction of a dislocation of the shoulder should be regarded with suspicion.

At the onset there is an initial sharp pain in those cases caused by indirect or muscular violence. However, the pain is transient and the patients frequently continue work, noting only weakness of the arm in elevation. It is not surprising that a number of cases are painless, similar to the absence of pain in finger tenotomies.

In cases of direct violence the symptom is that of weakness in abduction after the initial soreness has disappeared.

11. The mobility of the shoulder is one of the cardinal symptoms. The patients are in the first four weeks usually able to raise the arm from 45 to 60 degrees without pain, actively and passively. Passively, the arm can be elevated without pain to 180 degrees. This painless arc between 90 and 180 degrees is most significant. There is no restriction of the joint in stooping. In the late cases, however, adhesions take place and when the arm is raised passively to about 135 degrees, there is complaint of pain. This is due to the complicating subacromial bursitis.

111. One often notes that the arm can be lifted in the forward plane of the body sufficiently to be brought well above the head and possibly into complete elevation, whereas, in the lateral plane, it is impossible actively to raise it to the horizontal line; passively, of course, it can be pushed much further. When the arm is lifted to the right angle in abduction and the patient is directed to lower it, the arm drops more or less suddenly to the side, because the deltoid alone cannot support the weight.

In the old cases, the shoulder is usually limited by adhesions in and about the bursa or capsule, resulting from the organization of traumatic exudate or muscle spasm. In these cases, it is difficult to demonstrate the difference in the range of active and passive abduction which might be of diagnostic significance.

Local Examination. i. In the early cases, there is a noticeable lack of tone when pressure is made in the supraspinatus fossa. In the late cases, an appreciable hollowing is noted. There is usually an associated disuse atrophy, at this stage, of the deltoid and infraspinatus muscles.

ii. Upon palpation, very often a point of marked localized tenderness over the greater tuberosity is found. Pain may be noted when the dependent arm is rotated in the socket (incomplete tear). In the dependent position, the point of tenderness usually lies between the greater tuberosity and the tip of the acromion. Dawbarn[7] has pointed out that when the arm is abducted to 90 degrees this point of tenderness disappears, as the tuberosity passes beneath the acromion.

iii. Crepitus may be noted on manipulation and Codman has described a jog or a catch when the tuberosity passes inward under the acromion.

iv. We have noted that as the shoulder is manipulated backward and forward an unusual bony prominence can be felt to move under the examining fingers in the region of the bursa. This is the greater tuberosity which stands out more prominently because of the absence of the tendon mesially.

X-Ray Examination. X-ray examination is also very essential. Comparative x-rays and stereoscopic views of the disabled shoulder are valuable. Very frequently, the plates show several irregular areas of calcification in the tendon which are different in appearance from the common calcified deposit. In many cases, there is a notable rounding of the tip of the greater tuberosity with a widening of the sulcus between it and the head, which is thoroughly characteristic. This is caused by atrophy of the bone at the point of detachment of the tendon and has an important bearing upon treatment. Sometimes a cupping of the mesial border of the greater tuberosity with slight bony atrophy is noted.

In most cases I have found a depression radiographically in the sulcus between the greater tuberosity and the articular cartilage which has been confirmed at operation where the tendon has been avulsed from its anchorage. This "cupping" increases in depth by atrophy for a few weeks, then shows a fuzziness of bone regeneration followed later by a flattening of the fossa and the tip of the greater tuberosity and, finally, in late cases, marked bone density. I have scanned innumerable x-ray plates associated with other shoulder joint lesions and have not found any appreciable or distinct cupping except in supraspinatus avulsions. I believe it to be a distinct radiographic entity—yet in those cases with the lesion above the insertion, the plates are essentially negative. In one case we noted calcific changes in the torn fringe about the rent in the capsule which showed well by x-ray. The film exposure should be made so that the greater tuberosity shows well in the anteroposterior profile—namely, with the arm in slight internal rotation.

Differential Diagnosis. Rupture of the supraspinatus tendon must be differentiated from a subacromial bursitis, traumatic arthritis, infectious arthritis, and the osteoarthritic degenerative changes that come on with age. We believe that the diagnosis of the supraspinatus rupture is so sufficient by itself that further differentiation from the other conditions is not necessary. However, it should be borne in mind that the previous conditions mentioned may supercede and cloud the picture of a ruptured tendon.

Prognosis. Obviously, the earlier the treatment, the better the result, which holds true for practically all diseases and injuries. Those patients operated upon early made practically an uneventful re-

covery and were taken out of the partial permanent disability class and disposed of compensationally by a comparatively small but varying percentage loss. Those that were operated upon after the four weeks period had a greater schedule but were definitely improved. One patient operated upon nine months after the lesion was awarded two-thirds of an arm disability but six months later this was reduced to 25 per cent.

Treatment. The shoulder joint should be explored more frequently. The supraspinatus tear is amenable to surgical repair, but it should be borne in mind that in advanced cases, with adhesions, operation is questionable. These shoulders should be mobilized under a general anesthetic and physiotherapy directed to the development of the adjacent muscles to take up the compensatory loss.

The operation, per se, is quite a simple procedure:

1. The patient's shoulder is elevated by a sandbag and under general anesthesia the incision should be made on the anterior aspect of the shoulder extending downward from the acromioclavicular joint for a distance of three inches.

2. The deltoid fibers should be bluntly separated. To avoid damage to the anterior branch of the circumflex nerve, the incision should not be carried downward more than 3 inches. The bursa can then be exposed and incised in the same direction as the skin incision.

3. Upon opening the bursa, the supraspinatus tendon appears, usually torn at its insertion and that it has retracted beneath the acromion process for a variable distance. The tendon should be grasped with a strong Kocher clamp and drawn distally to its anchorage.

4. The recovery of the tendon not infrequently requires an embarrassing period of time, since it is hampered by the narrow working space. In such cases, the tendon frequently falls behind the head and is aggravatingly difficult to recover. We have devised a double curved

hook which is modeled after a shoe-button hook, with a gently curved shank at right angles with the head of the hook and so curved to fit the head of the humerus. The loose tendon end can be scooped out of the posterior part of the capsule. This is facilitated by the assistant pulling the arm downward and outward.

5. With an osteotome, the sulcus between the articular cartilage and the greater tuberosity should be deepened so as to provide an abutment for the anchorage of the end of the tendon. This channel or gutter is usually about 1 inch long, $\frac{1}{4}$ inch broad and about $\frac{1}{2}$ inch deep.

6. Four drill holes made through the lateral surface of the humerus below the greater tuberosity into the gutter serve to secure the tendon to its bed.

7. The edge of the thickened supraspinatus tendon is then inserted into the channel and secured by a running double mattress suture of heavy silk. This suture is inserted inward through hole No. 1, piercing the tendon, brought out of hole No. 2, in hole No. 3, out hole No. 4, then back in hole No. 3, out hole 2, and then square knotted outside between holes 1 and 2. Avoid making an odd number of drill holes as the tie will necessarily terminate inside.

8. The capsule is then closed with interrupted sutures of chromic catgut and the wound repaired in the usual manner with absorbable material for the skin.

9. The extremity is immobilized in a plaster of paris spica, the arm in 90 degree abduction and external rotation, with the elbow at right angles.

10. In contradistinction to the method employed by Dr. Codman of making a saber incision, we have found that in those cases where the supraspinatus tendon has retracted so far back as not to be able to be found, or is more or less atrophied, into the capsule of the joint, by making a small incision above the superior border of the spine of the scapula into the supraspinatus fossa and following the supraspinatus muscle down towards its tendon attach-

ment, we were able to obtain the severed end rather readily. We believe this procedure causes less anatomic damage and is preferable to impairing the security of the clavicle and the acromioclavicular joint.

11. The after treatment should be as spica is removed. Active abduction should be permitted with caution. There should be a fair return of function at the end of three months.

A tabulation of the cases observed is appended. Twelve submitted to operation.

Name	Sex	Age	Cause of Injury	Symptoms	X-ray	Amount of Abduction in Degrees
G. G.	M	48	Fell down stairs, landing on left shoulder	Pain and tenderness	Irregularity of the greater tuberosity	90
P. E.	M	60?		Pain	Irregularity of the greater tuberosity	Atrophy
C. D.	F	48	Fell on left shoulder	Crepitation		60
C. H.	M					
J. A.	M	68	Bone fell on left shoulder	Crepitation		135
J. G.	M					
A. M.	F	28	Reaching up to shelf	Crepitation and pain		135
H. M.	M	53	Jerked on crane, dislocation of shoulder	Pain		90
A. P.	M	62	Fell on right shoulder	Dislocation	Cupping	135
J. B.	M	45	Fell hanging on	Tenderness		100
I. B.	F	53	Fell on right shoulder	Tenderness		135
F. C.	M	30	Hit by train	Pain	Cupping	90
A. G.	M		Fell on left shoulder			80
E. M.	M					135
E. W.	F	51	Fell against railings	Pain		90
P. C.	M	60	Dislocation and sprain fracture of greater tuberosity		Cupping	45
V. H.	M					
C. O.	M	25	Comminuted fracture of the greater tuberosity	Pain		70
R. P.	M	26	Block of wood fell on shoulder			
J. E.	M	29	Fell on right shoulder		Spicule on the greater tuberosity	75
O. F.	M	30	Fell on left shoulder		Fracture of greater tuberosity	75
W. F.	M	25	Fell on right shoulder	Tenderness		90
J. O'D.	M	50	Case fell on shoulder	Atrophy in supraspinatus fossa		90
L. S.	M	57	Struck by car		Cupping	80

follows: apply spica with the arm in 90 degree abduction and slight external rotation in order to place the least tension on the tendon. The spica should be removed in three weeks and the arm fixed at 75 degree abduction for a few days and gradually lowered to the completely dependent position in an additional week. Physiotherapy should be given as soon as the

CONCLUSIONS

1. Rupture of the supraspinatus tendon occurs in approximately two out of every 100 shoulder injuries.

2. The unoperated cases represent a very high economic loss and place many patients in the permanent total class.

3. The entity is unique and the diagnosis should not be missed.

4. The average age of incidence suggests preexisting calcific pathology.

5. Early diagnosis is indication for operation.

6. In early operation, prognosis is good.

7. The rational treatment is operative.

8. The shoulder joint should be explored more frequently.

I am deeply indebted to my assistant, Dr. David J. Graubard, for his time and interest in collecting the case records and reviewing the anatomy and literature.

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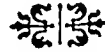
ELBOW INJURIES OF CHILDHOOD RESULTING FROM MEDIAN EPICONDYLAR SEPARATIONS

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MEDIAN epicondylar epiphyseal separations are being recognized more frequently than formerly, lateral condyle of the humerus, and fractures of the coronoid process.

When one comes to recognize the dis-
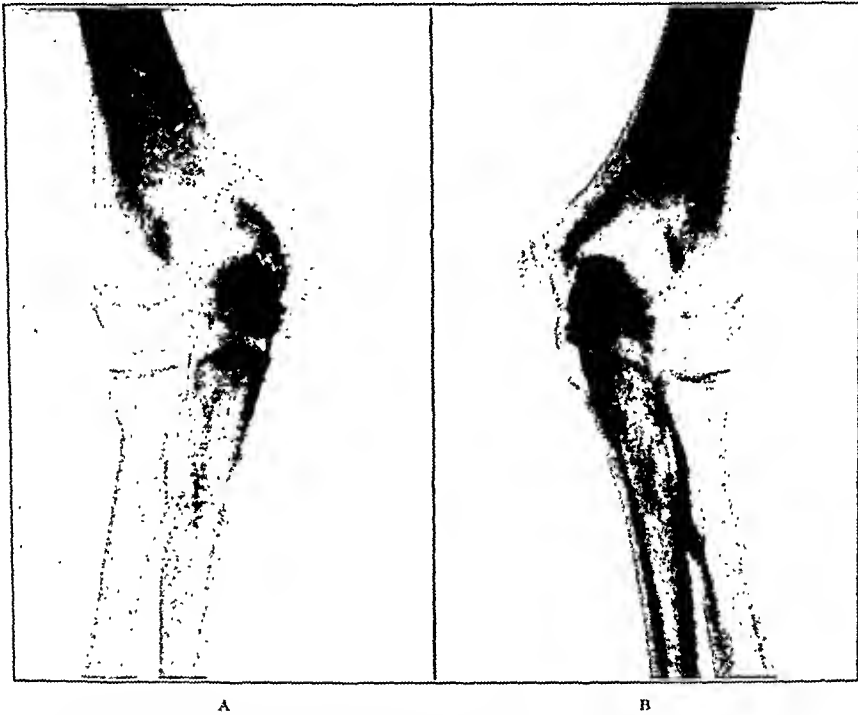
FIG. 1. Anteroposterior roentgenograms of both elbows of a boy 11 years of age. A, a separated and slightly displaced median epicondylar epiphysis, as compared with B, where the epiphysis is seen in its normal position. In this instance the epiphysis has two centers of ossification. (From Dunlop, in *J. Bone & Joint Surg.*, 17: 577, 1935.)

and likewise the importance of such injuries in relation to other elbow injuries in adolescence. When Cotton, in 1929, wrote of the end result of neglect in such cases, the real significance of epicondylar separations was not at all understood. Only in 1935 was complete lateral dislocation of the elbow shown to be the result of such separations, and, of even greater significance, fracture injuries of the lateral side of the elbow, such as fracture of the head or neck of the radius, fractures involving the turbed mechanics accompanying traumatic separation of the median epicondyle, one gains a very clear understanding of the injury in each of its phases. Let me describe just what takes place:

The bones of the medial side of the elbow are held in their relation to one another as in all joints, by heavy ligamentous tissue, and to the median epicondyle is attached a very strong group of muscles composed of the flexors and pronators of the forearm. In the adult this bony promi-

nence not only acts as an attachment and leverage point from which this group of muscles operates in performing its func-

The mechanism is as follows: The child falls in such a way as to put a quick hard pull on the flexor group of muscles, which

Fig. 2. Anteroposterior roentgenograms of both elbows. In comparing these two films, the first thing to be noted is the absence of the median epicondyle epiphysis from its normal position in A. Next, one observes a widening of the joint space on the median side of the same arm, and by careful inspection the shadow of the displaced median epicondylar epiphysis can be seen lying in the joint space between the shadow of the coronoid process and the median condyle. It was this mass which held the bones of the elbow joint apart. (From Dunlop, in J. Bone & Joint Surg., 17: 577, 1935.)

tion, but it also acts somewhat as a pulley, about which the ulnar nerve passes from the upper to the lower arm. This mass of bone is developed from a separate epiphyseal center, and is shown as a distinct epiphyseal growth in radiographic studies of boys up to the fifteenth year.

From the beginning of increased activity of the growing child, especially of a boy, and up to the time of closure of the epiphyseal line between the epicondyle and the shaft of the humerus, is the period when epicondylar separations take place. The mechanism of the injury in all its phases is most interesting and it is only through a thorough understanding of this mechanism that one can obtain a true conception of all of this group of injuries.

is attached en masse to the internal epicondyle. The epicondyle, with its muscular attachments, becomes separated from the shaft of the humerus by a fracture occurring through the cartilage which forms the epiphyseal line. As the epicondylar mass separates, the ligamentous attachments of the medial side of the elbow tear, and this tear is in extent directly in proportion to the continuation of the force, even up to the point where all of the ligaments of the medial side of the elbow joint have been ruptured. With the tearing of this ligamentous support the epicondyle is drawn down and forward by the contraction of these forearm muscles attached to it, and with the support of the medial side of the joint having been lost, the joint opens or
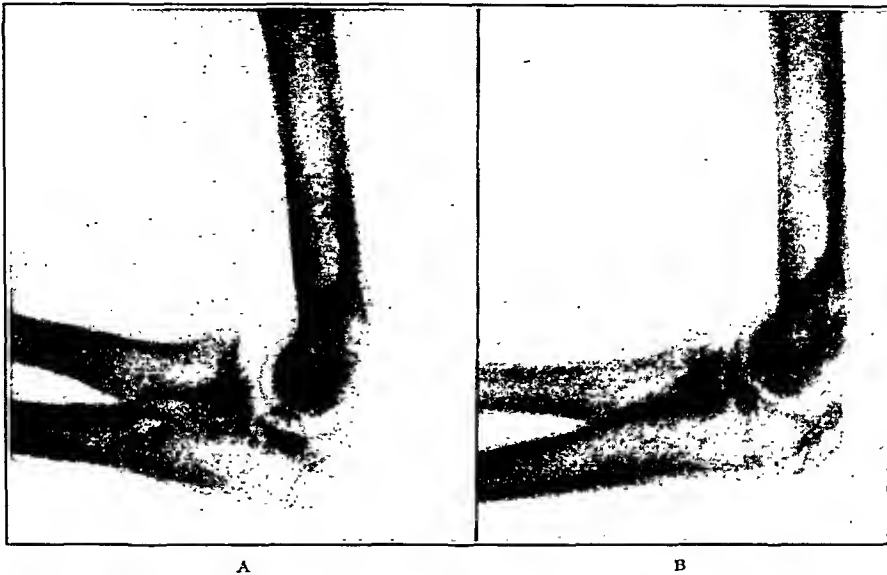
FIG. 3. Roentgenograms before and after operation. A, lateral view of Fig. 2A showing the displaced medial epicondylar epiphysis in the elbow joint, resulting in a widening of the joint space. B, lateral view of the same joint after the removal of the median epicondyle and its fixation in its regular position, the joint space returning to the normal. (From Dunlop, in *J. Bone & Joint Surg.*, 17: 577, 1935.)
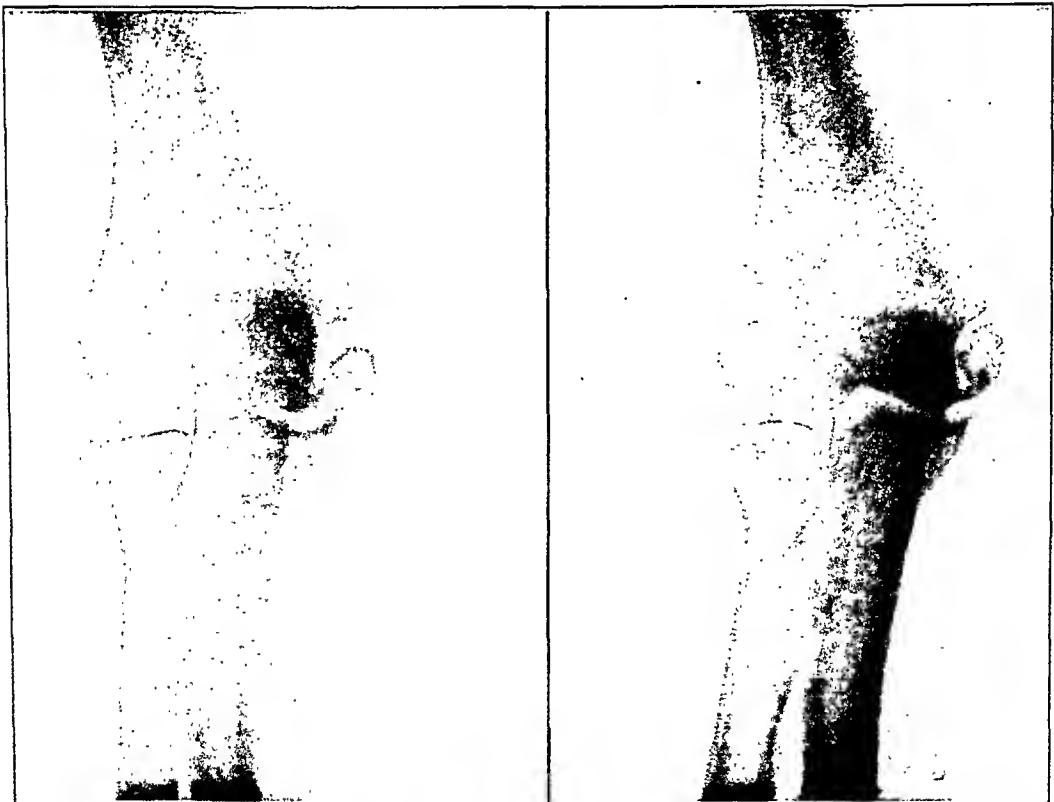
FIG. 4. These roentgenograms show poor results of operations where absorbable sutures were used, and where the shaft of the humerus was not drilled as a point of fixation for the sutures. The epicondyle has been drawn out of position by the constant pull of the flexor pronator group of muscles attached to it. (From Dunlop, in *J. Bone & Joint Surg.*, 17: 577, 1935.)

A   B
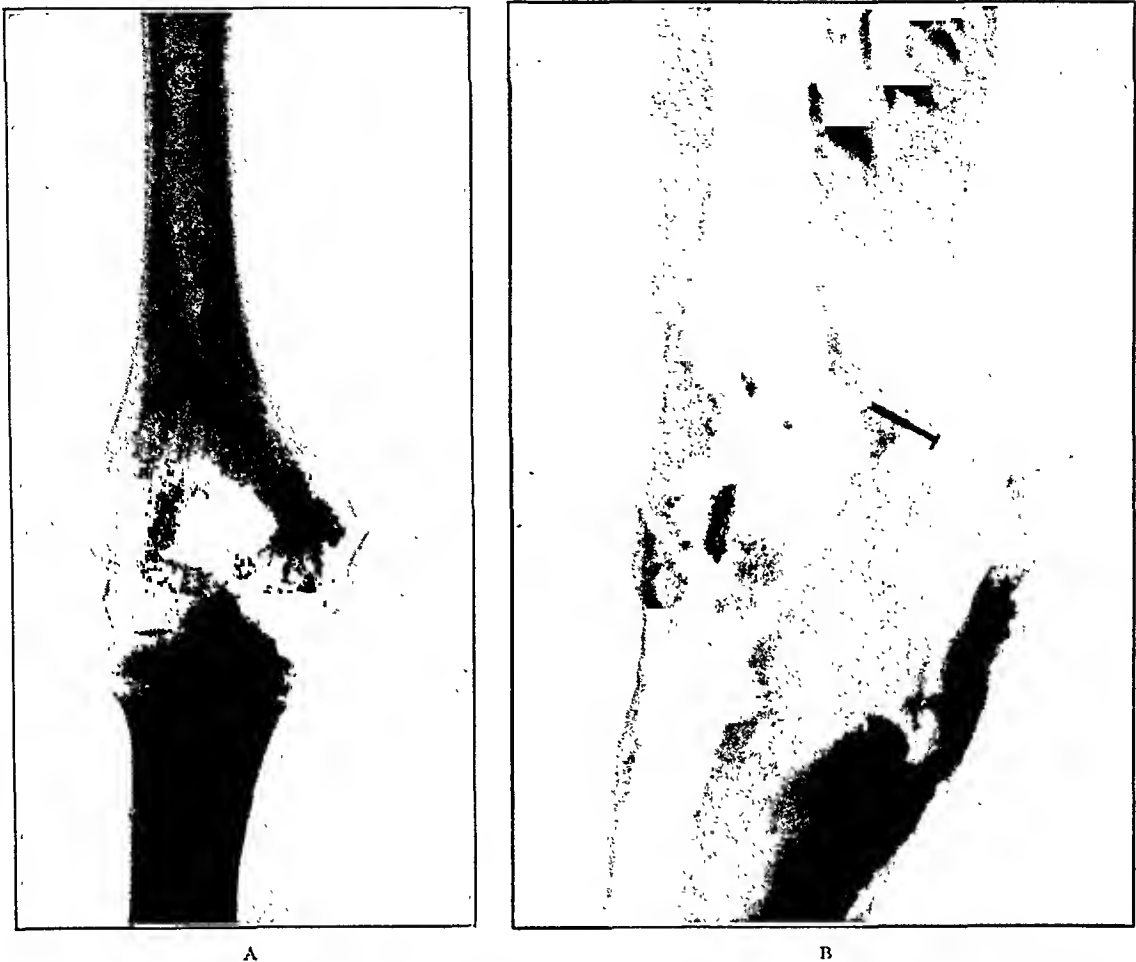
FIG. 5. A, in this case the shaft of the humerus was drilled as a point of counter-fixation for absorbable sutures and yet approximation was not perfect, though a great improvement over the result obtained in Figure 4. (From Dunlop, in *J. Bone & Joint Surg.*, 17: 577, 1935.) B, a metal nail was used in this case for fixation. Lately some form of metal nail has been used as it assures much more accurate replacement and ease of fixation. It is removed in about six weeks after operative reduction.
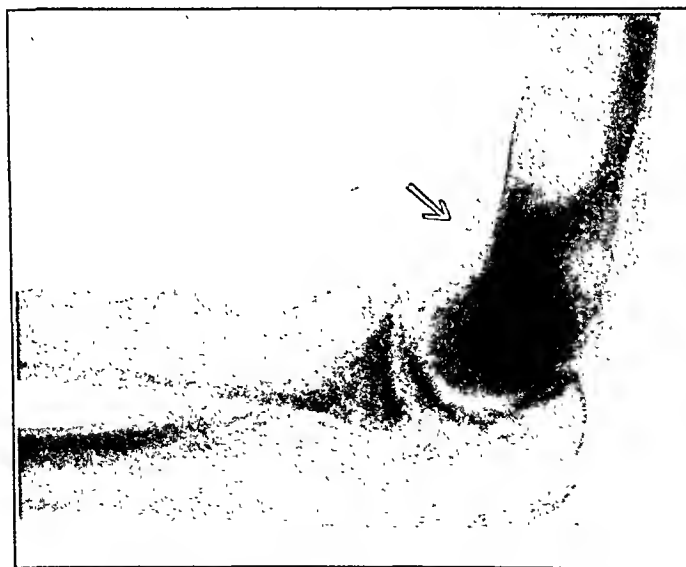
FIG. 6. The excess bone in the antecubital fossa is the remains of a considerable deposit which has gradually disappeared. This is thought to be due to the periosteal damage at the time of injury. In this case closed reduction was successfully carried out. (From Dunlop, in *J. Bone & Joint Surg.*, 17:577, 1935.)

separates on the medial side like the opening of a book. The loosened epicondyle, which has been drawn down and forward,

If this original force continues further, the lateral supporting soft structures of the elbow are also torn, which may cause
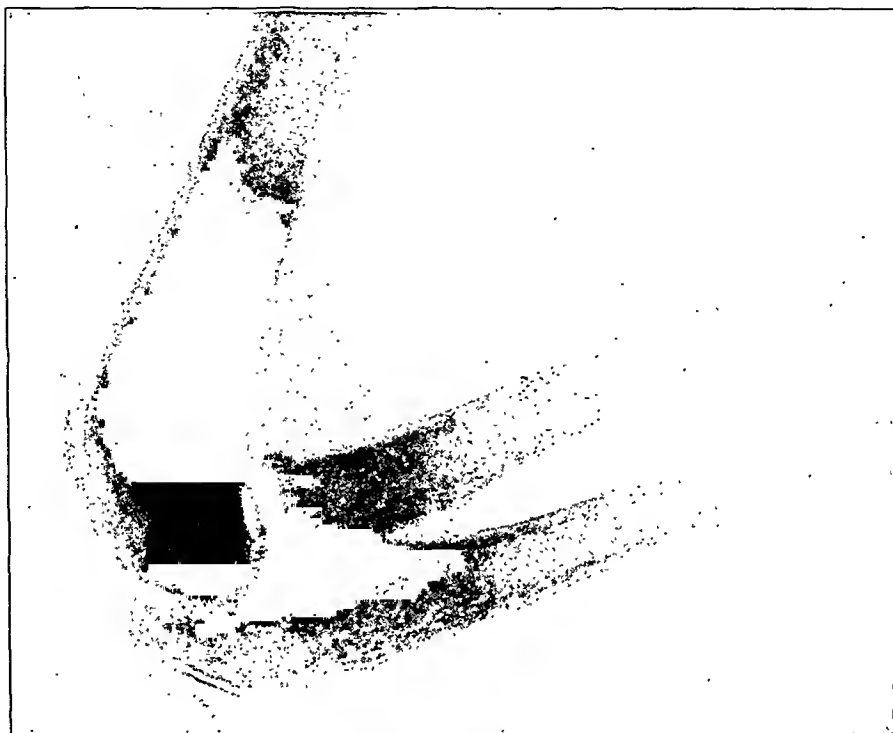
FIG. 7. This case is one of the most instructive, as a careful study of the roentgenogram will show. The boy had a dislocation. Many attempts to reduce it were made under anesthesia on two or more successive days, considerable force being used. All were unsuccessful. It had not been recognized that the median epicondylar epiphysis had become dislodged and had been caught in the joint between the olecranon and the medial condyle, and apparently by the successive manipulations this bony misplaced epicondylar mass had been ground into the bony structure of the olecranon. As a result of this unrecognized condition and the resulting damage to the joint surfaces, the elbow joint became stiff. Due to this unfortunate experience confidence in medical care has been lost and the elbow joint remains in a stiff flexed position. An arthroplasty unquestionably could offer much improvement. (From Dunlop, in *J. Bone & Joint Surg.*, 17:577, 1935.)

has a tendency to fall into this separated inner side of the elbow joint. At this point the joint may close and catch the epiphysis within it.

If the original force of the injury is sufficient, an even wider separation of the elbow joint may take place, to the point of compressing the bones forming the lateral side of the joint, namely, the lateral condyle of the humerus and the upper end of the radius. If this compression is sufficient, fractures occur, and we have examples of fractures of the head or neck of the radius and of the lateral humeral condyle.

fracture sprains, such as the tearing away of the coronoid process, or even a complete lateral dislocation of the elbow joint.

The important thing to understand is that this whole sequence starts with the pulling away of the internal epicondyle as a result of a fracture occurring through the cartilaginous epiphyseal line.

DIAGNOSIS

Recognition of this condition is not difficult when one understands the sequence of injuries that may occur.

A child between the ages of 5 and 15 has an elbow injury resulting in a questionable dislocation. An attempt at reduction,

2. A widening of the joint space, especially to the medial side, as compared with the roentgenogram of the opposite elbow.
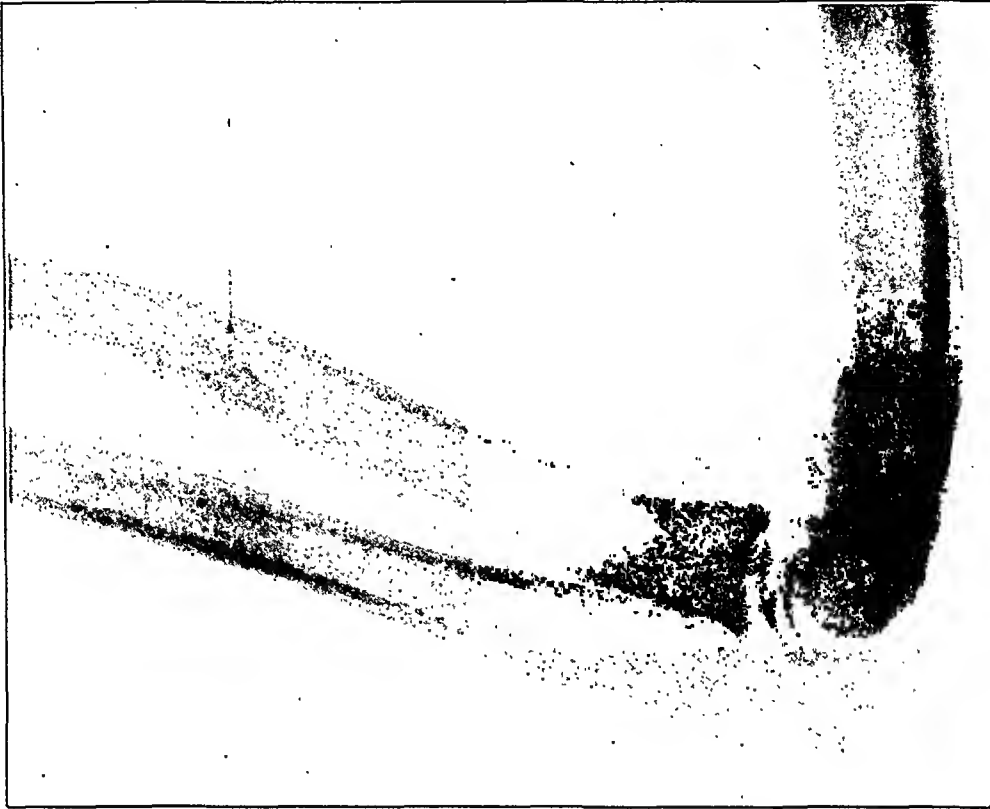
Fig. 8. A later roentgenogram of the case shown in Figure 7. The excessive bone overgrowth in the antecubital fossa is unquestionably due to the extensive damage to the soft tissues as a result of the original injury. If much dislocation occurs the supporting ligaments of the elbow are either torn across or what is more likely, torn from their bony attachments. They undoubtedly pull away much neighboring periosteum, and it is this periosteum which supplies the seed for bone production in an exceptionally fertile bed of damaged soft tissue and hemorrhage. No further treatment was given and this was the final result. (From Dunlop, in *J. Bone & Joint Surg.*, 17:577, 1935.)

usually made by a playmate or some passerby, is only partially successful as motion may be decidedly restricted, and any attempt at motion is accompanied by muscle spasm and acute pain in the elbow joint. The roentgenogram, as interpreted, may not show the cause of the disability, or at least it does not reveal any visible fracture. However, a comparative x-ray study of the two elbow joints will disclose the nature of the pathology. A careful study of the original film of the injured joint may show any one of several diagnostic points:

1. Absence of the median epicondyle from its normal position when compared with the roentgenogram of the opposite elbow.

3. A loose fragment within the elbow joint between the medial condylar surface of the humerus and the olecranon process of the ulna.

These are the more usual findings when the injury has proceeded to a certain point and then stopped. They are not the findings in the mild cases where there is merely a slight or moderate degree of tearing of soft tissue with accompanying moderate misplacement of the epicondyle downward and forward. Nor are they the findings when a complete lateral dislocation of the elbow joint has taken place, nor when compression of the lateral side of the joint has caused fracture of the head or neck of the radius or a fracture of the lateral condyle of the humerus. However, when
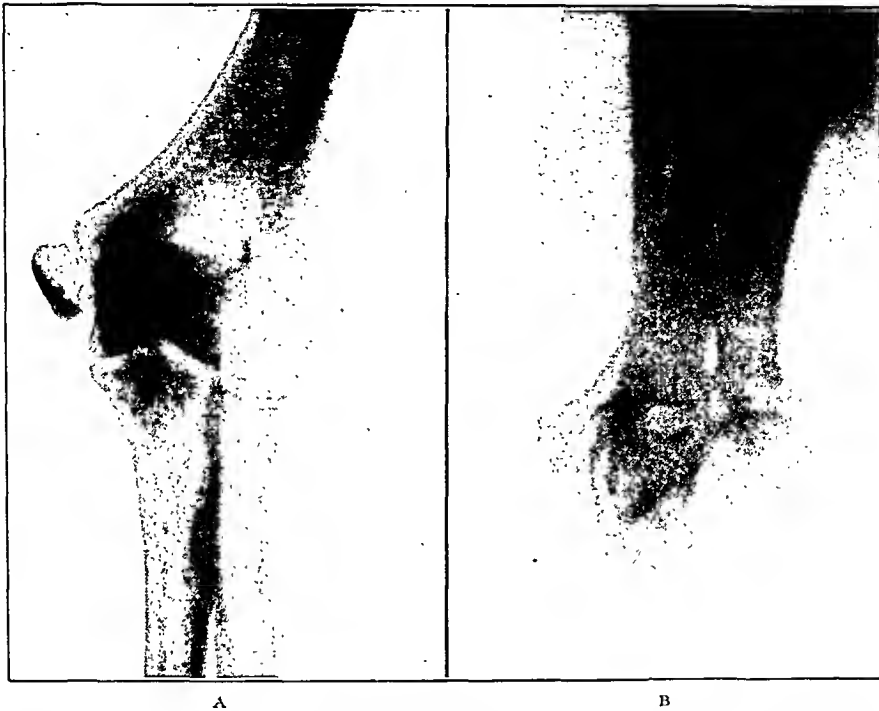
FIG. 9. The only case treated by closed reduction. A, moderate degree of separation of the medial epicondyle. B, the flexed elbow shows the medial epicondyle in position six weeks after reduction. Healing is taking place. (From Dunlop, in *J. Bone & Joint Surg.*, 17: 577, 1935.)

FIG. 10. Same case as in Figure 9, showing two stages of repair and growth development. A, roentgenogram taken six months after injury. B, roentgenogram taken four and one-half years after injury to the epiphyseal line. The epicondyle going on to normal development. (From Dunlop, in *J. Bone & Joint Surg.*, 17: 577, 1935.)

such injuries have occurred one must be alert to locate the separated median epicondyle, for in these cases any reduction of the dislocation or fractures only partially

4. A fracture of the head or neck of the radius.

5. A fracture of the lateral humeral condyle.
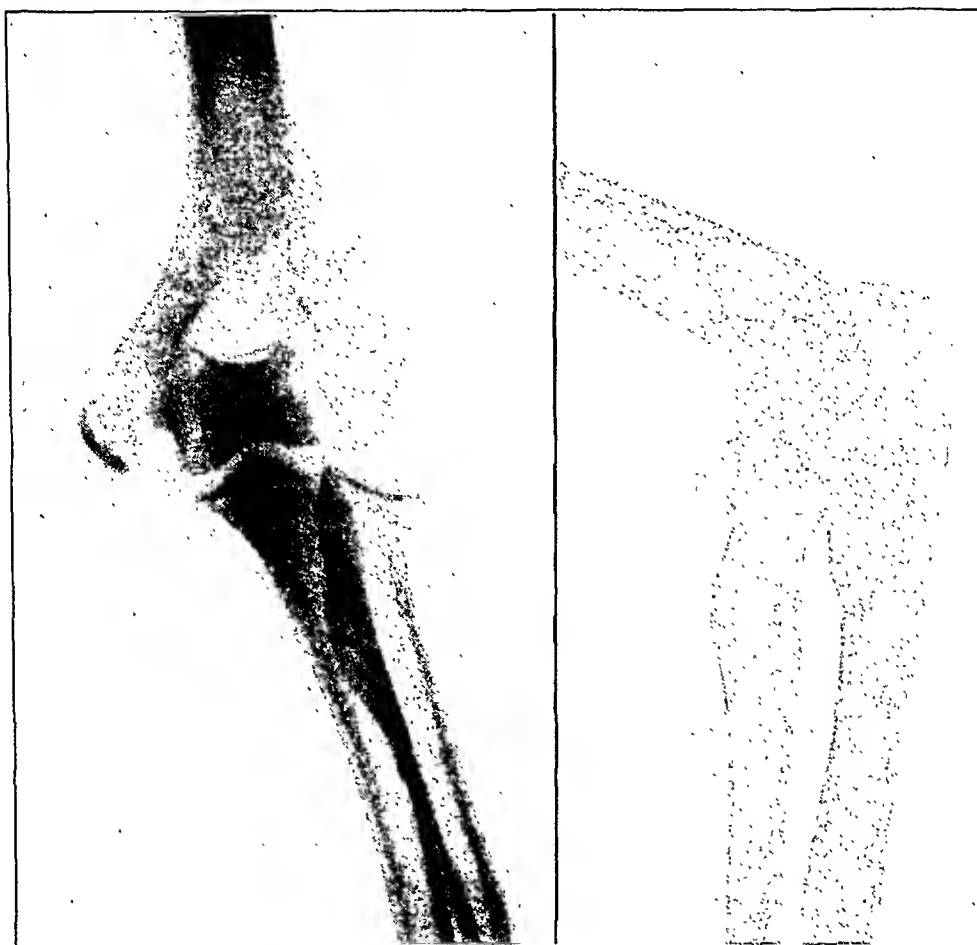
Fig. 11. a, fracture of the head of the radius accompanying a separated median epicondyle. b, same case after reduction of the fracture and healing have taken place. There is a small bony excrescence at the old line of fracture. (From Dunlop, in *J. Bone & Joint Surg.*, 17: 577, 1935.)

cares for the injury. The damage to the soft structures on the medial side of the elbow joint must be repaired and the separated epicondyle replaced and fixed in position. It can thus be seen that the injury may vary from the slightest "giving" of the median epicondyle to:

1. A moderate separation with only a slight tear in the soft tissues.

2. A misplacement which allows the epicondylar epiphysis to enter and become engaged in the medial side of the elbow joint.

3. A complete lateral elbow joint dislocation.

6. Pull-away fractures of the coronoid process of the ulna.

TREATMENT

The slight separations of the median epicondyle may possibly be treated by manipulative replacement and fixation until union has taken place. This was done in one instance by passing a strip of adhesive up the forearm with the elbow fully flexed at time of reduction, and counter-fixing it on the upper arm, the adhesive passing around the replaced epicondyle and holding it in its position against the shaft of the

FIG. 11C.
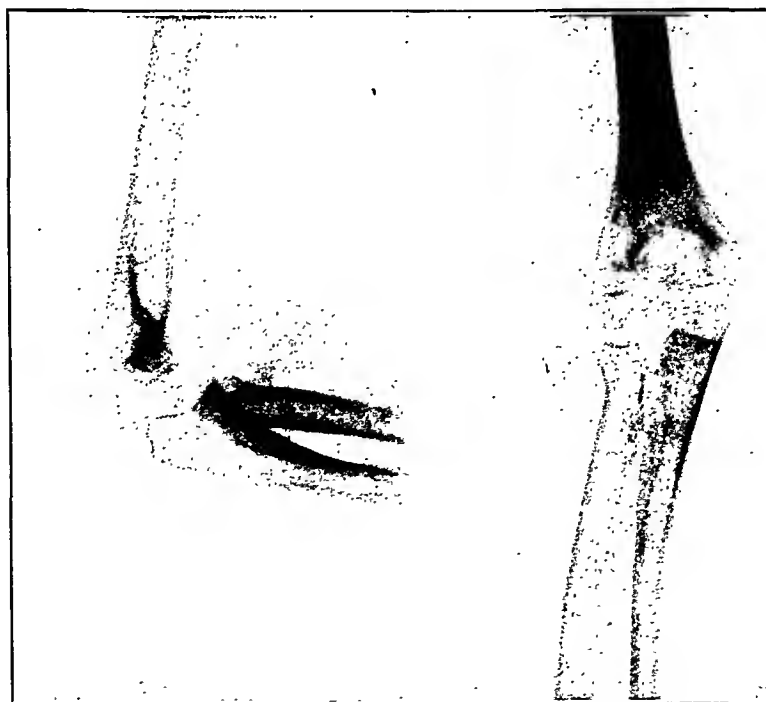
FIG. 11D.

FIGS. 11C, D, and E. Fracture of the lateral condyle of the humerus. These are the first illustrations demonstrating this lesion accompanying medial epicondylar injuries and compression of the lateral side of the elbow joint in extension. (Fig. 11E on page 319.)

Fig. 11E.

Fig. 12. Anteroposterior view, showing the medial epicondyle below the medial condyle of the humerus, with a partial lateral dislocation of the bones of the forearm. (From Dunlop, in *J. Bone & Joint Surg.*, 17: 577, 1935.)
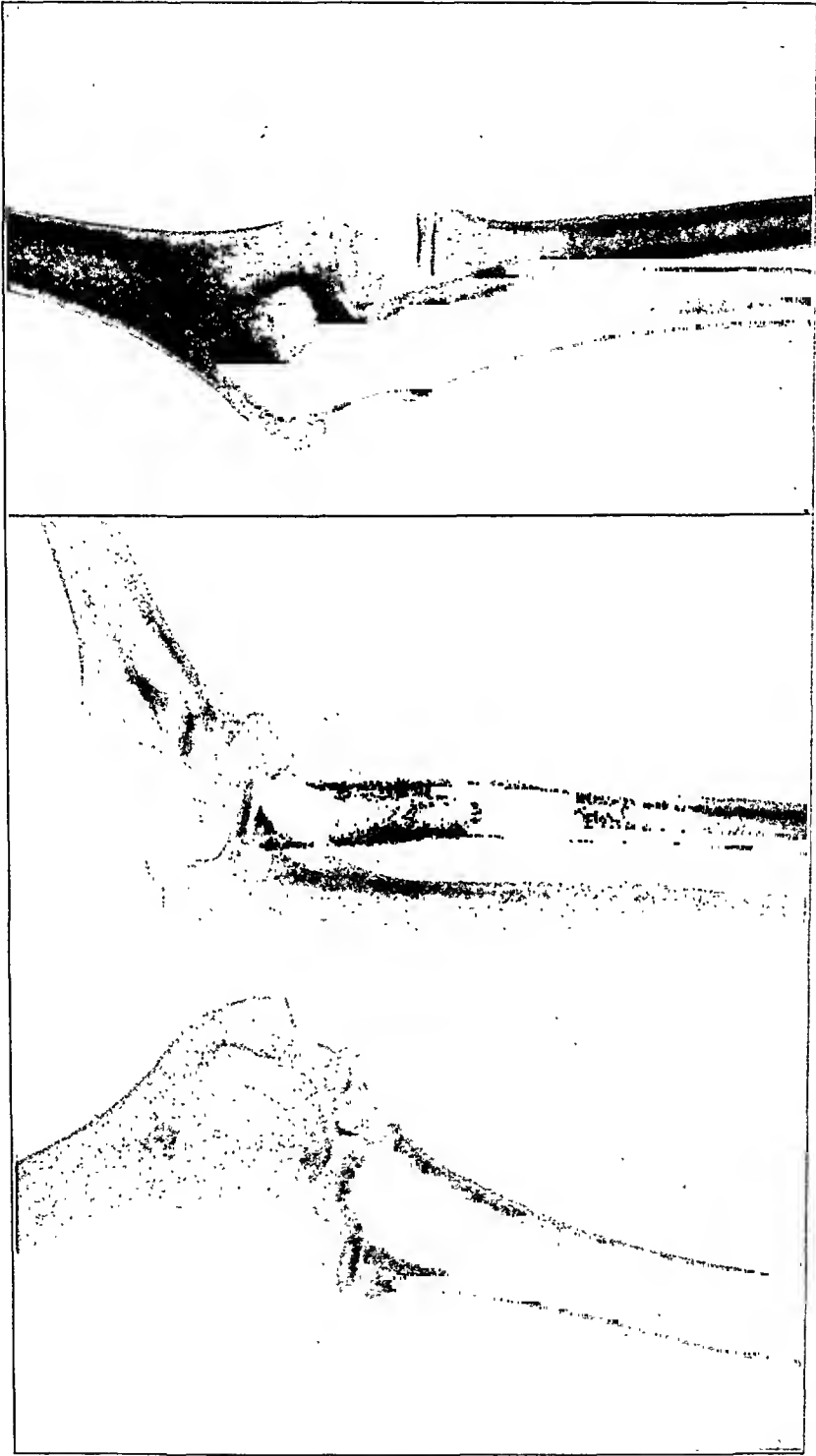
FIG. 13. A and B, complete dislocation of the elbow laterally, with the medial epicondyle greatly displaced. C, anteroposterior view of the opposite elbow, showing the epicondyle in its normal position. Compare this with the contour of the humerus in the dislocated elbow (Fig. 13A), which illustrates the difficulty in recognizing the absence of the epicondyle when separated and dislocated. (From Dunlop, in J. Bone & Joint Surg., 17: 577, 1935.)
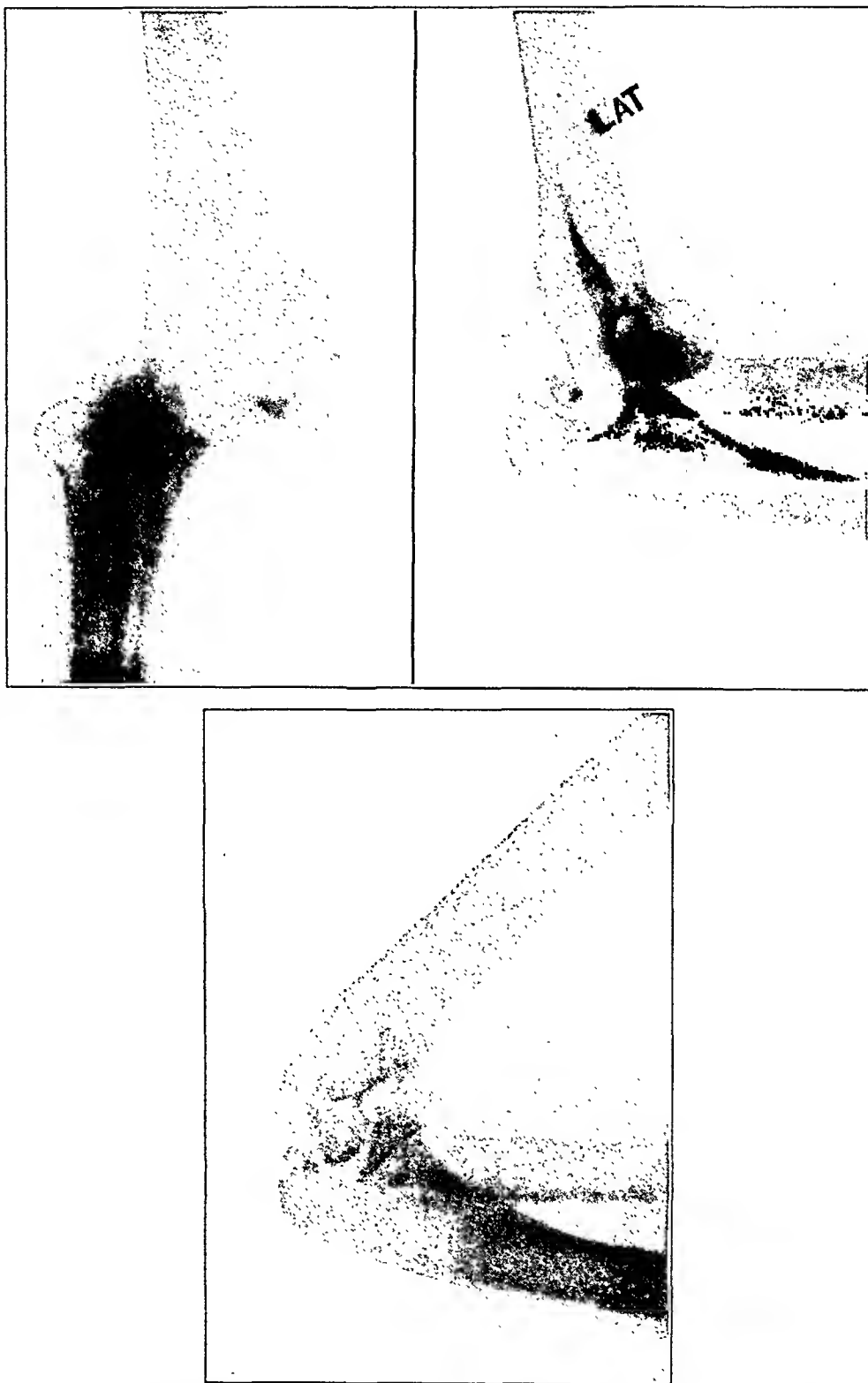
Fig. 14. This series of roentgenograms is of especial interest because the mechanism of the injury was not at first recognized. Following a closed reduction of the dislocation, the median epicondyle can be seen in the antecubital fossa. An open repair was then done and the median epicondyle was replaced and fixed in its normal position and the rent in the soft tissues sutured. (From Dunlop, in *J. Bone & Joint Surg.*, 17: 577, 1935.)
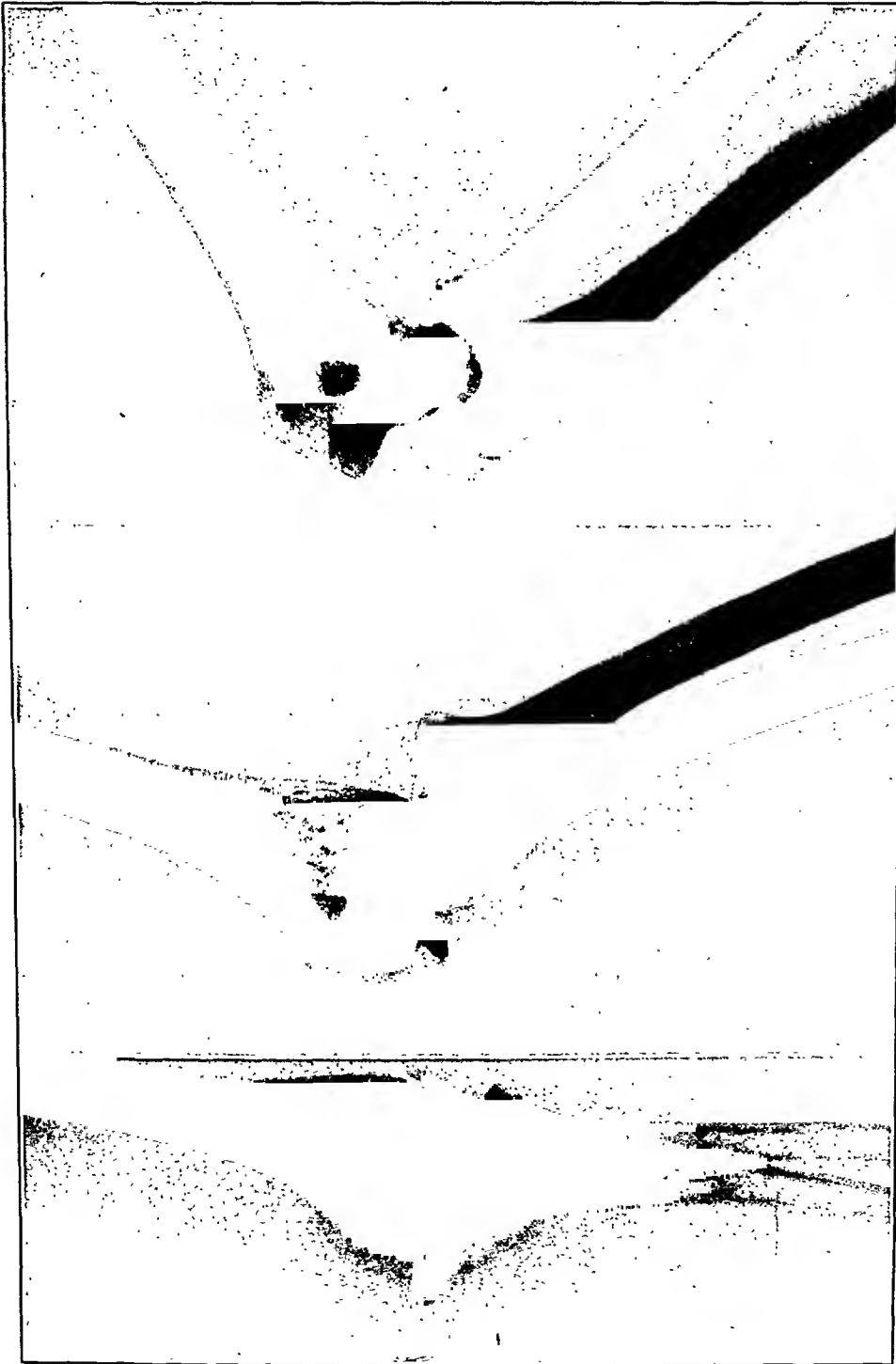
FIG. 15. These three anteroposterior roentgenograms are shown together to demonstrate more forcefully the mechanism of lateral dislocation. A, the median epicondylar epiphysis is seen separated from the shaft of the humerus and lying free to the medial side of the elbow joint. No other change in relation of the bones of the elbow joint has taken place. B, the median epicondylar epiphysis is now drawn down under the median condyle. The ulna is displaced laterally under the lateral humeral condyle and the head of the radius is free from bony support. C, the forearm is displaced to a 90 degree angle to the upper arm and the median epicondylar epiphysis is now drawn laterally to lodge under the lateral condyle. The head of the radius now rests against the side of the lateral condyle. In such a dislocation the soft supporting structures on the lateral side of the elbow must have been torn, otherwise fractures of the lateral side of the elbow would have occurred due to compression.

humerus. The whole arm was fixed in complete elbow flexion.

Where, however, there has been sufficient tear of the soft tissues to allow much displacement of the separated epicondyle, open repair should be immediately undertaken. The reasons for this are threefold:

1. Reduction and fixation in its proper position is almost impossible to attain by manipulation.

2. Repair of the rent in the soft tissue is important to prevent adhesions constricting the ulnar nerve.

3. Restoration of the flexor pronator group of muscles to their normal relation is of great importance to assure their normal function.

In those cases where the epicondyle has become caught within the joint it becomes absolutely necessary to remove it with as little damage as possible. It has been proved that closed manipulative attempts have permanently injured the joint surfaces, and they should, therefore, never be attempted.

OPERATIVE PROCEDURE

The skin incision should be well posterior to the normal location of the median epicondyle on the shaft of the humerus. It should extend at least an inch above this normal location and should go down the medial side of the elbow joint to at least a half inch below the joint line.

The reason for this location and extent of incision is to allow free observation of all the structures to be worked on and to allow for proper fixation of the epicondyle when it has been brought up into position. If the incision is too far forward it makes this fixation procedure very much more difficult. The extent of the incision also allows for full observation of the tear in the soft parts and of the muscle bundle attached to the separated epicondyle. It is the recognition of this muscle bundle leading to the epicondyle, which is frequently found firmly fixed within the joint. The incision must also allow for such observation of the

damaged soft tissues as will facilitate their proper repair.

After the skin incision is made it is wise to locate the ulnar nerve, which will be found anterior to its normal position, as it is normally held posterior by the epicondyle. The location of the ulnar nerve and retraction by a piece of tape during the repair operation is a good safeguard to prevent its injury when sewing up the rents in the soft tissue.

The next procedure is to identify the muscle bundle of the flexor pronator group. This will lead to the loosened median epicondyle. If the epicondyle is found held within the joint it will be necessary to open the joint by grasping the upper arm and forearm, and forcing it open only sufficiently to relieve the grasp on the epicondyle, when it will be easily removed by grasping it with a towel clamp. With the use of this same towel clamp the epicondyle with its attached muscle bundle can be forced up into its normal position. This maneuver can be helped by elbow flexion. The fractured surface of the epicondyle has a smooth glass-like appearance, and closely resembles the inner side of an oyster shell.

The position on the humeral shaft from which it has been detached is found at the upper or proximal end of the rent in the soft tissue and is recognized by its duplication of the fractured surface found on the separated epicondyle. These two surfaces are then fitted together and fixed in this position, preferably by a non-rusting metal nail of small caliber. It will be necessary to have the elbow flexed to accomplish this.

The torn soft tissues are next carefully approximated by an absorbable suture, especial care being taken to avoid the ulnar nerve. The skin is closed and some fixation applied to prevent the arm from straightening until union has taken place.

If there have been extensive bone injuries, such as complete lateral dislocation, or fractures of the head of the radius, or of the lateral condyle of the humerus, these conditions must be cared for in the usual way.

It has been found that it is not difficult to reduce fractures of the head of the radius by manipulation before reduction of the epicondyle. In other instances, an open reduction has been accomplished at the same time through a separate incision.

Some surgeons have insisted on removal of the epiphysis, but this should be severely condemned as bad practice, because it not only destroys the most natural position for muscular action, but should an attempt be made to make a new muscular attachment many adhesions would necessarily form with great danger to ulnar nerve constriction, of which Dr. Cotton so accurately wrote.

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EXPLORATION of the wound is essential in all wounds which go deeper than the subcutaneous tissues, and particularly is this true of punctured wounds.

VOLKMANN'S CONTRACTURE

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DURING recent years there has been increased interest in Volkmann's contracture in certain fracture clinics. This interest has been stimulated not so much by improved methods of treatment of the condition, as by the introduction of various procedures which aim to prevent the development of the contracture. In the past, although no one individual may have had the misfortune to encounter any considerable number of cases, they have occurred more often than is generally supposed.

In 1909, Thomas[1] reviewed the literature and found reports of 103 cases from the time of Volkmann's original report in 1869 to the time of Quimby's report in 1908. Thomas added four cases of his own. In 1907, Jones[2] stated that he had seen twenty-four cases, nineteen of which were associated with a fracture. In 1914, Murphy[3] presented six cases from the "large number" which he had seen. There were 128 patients with the condition at the Mayo Clinic[4] from 1910 to 1927.

Today, the important fact to recognize and remember is that with our present knowledge about the condition, it can be prevented.

In most instances, Volkmann's contracture is a complication of fracture of the elbow, usually supracondylar fracture of the humerus in children. It is commonly referred to as Volkmann-Lesser paralysis, Volkmann's ischemic paralysis, and Volkmann's ischemic contracture. The latter term is preferable, as it correctly describes the condition.

Much of the interest in Volkmann's contracture lies in the fact that everything about the condition is not yet known. For many years, various men have entertained numerous and at times conflicting views concerning the cause of the contracture.

Richard von Volkmann, after whom the contracture was named, first described the condition in 1869.[5] He observed a contracture of the hand which he believed was due to tight bandaging. He felt that the tightly bandaged splint interfered with the arterial circulation, thereby robbing the muscles of oxygen, causing their death. This original view conformed more nearly with our present knowledge of Volkmann's contracture than did some of those which followed.

Volkmann's classical article[6] dealing with contracture of the hand was written in 1881. By this time, he had had the opportunity of observing a number of cases which had led him to make certain definite conclusions about the condition. He stated that the difficulty was due to the shutting-off of the arterial blood supply, plus the obstruction of the venous outflow. He felt that the hard, board-like condition which resulted was similar to rigor mortis. Since the contracture and paralysis followed the injury almost immediately, he did not believe nerve injury was the primary cause. He pointed out that contracture followed at a later date in nerve injuries. He described the means and methods of overcoming the contracture by forcible extension of the fingers with splints and traction.

Bardenheuer[7] believed that the condition was wholly due to vascular disturbance and that the degeneration of muscle was caused by toxins which accumulate as a result of obstruction of venous outflow. Thomas,[1] on the other hand, felt that the condition could not result from circulatory disturbance alone, and considered nerve injury as the underlying causative factor. And thus it has gone down through the years, one authority claiming the causative factor to be injury to arterial circulation, another, obstruction of venous outflow, while others championed nerve injury or

combination of nerve and circulatory damage.

Experimental work on animals has borne out the observation that obstruction of the circulation alone does not cause the contracture. It has long been an accepted fact that obstruction of a main artery in an extremity causes dry gangrene with flaccid paralysis; obstruction of a principal vein results in wet gangrene. Ligation of vessels of an extremity has produced flaccid paralysis with or without gangrene. Trauma to nerves also results in flaccid paralysis with lengthening of muscles at times, but never fibrosis and contracture.

The picture which ischemic contracture presents is quite different from that produced by injury to nerve alone or obstruction of circulation alone. In the former, the muscles are destroyed to a great extent. Fibrosis with the accompanying degeneration occurs, resulting in the shortened cord-like structures which resemble scar tissue more than muscle cells. Nerves may be involved in the fibrosis causing injury to them. But the picture of ischemic contracture remains the same—the shortened cord-like flexors and the claw hand.

It becomes evident that there is something more than circulatory and nerve disturbance in the production of Volkmann's contracture. That added factor is pressure, extrinsic or intrinsic. Pressure follows an injury to the elbow region, associated with a supracondylar fracture. Pressure impairs the circulation, both arterial and venous. Pressure, plus the infiltration of the tissues with blood, results in ischemic necrosis. Hemophilia alone has caused Volkmann's contracture. The experimental work of Jepson[8] shows that a combination of factors, rather than any one factor, contributes to the production of the condition.

The pressure may be extrinsic, such as results from wooden, metallic, or plaster of Paris splints applied too tightly; or intrinsic, resulting from too acute flexion of a swollen elbow or pressure from a subfascial hematoma. The result is the same. Pressure impairs the circulation and directly injures the tissues, resulting in fibrosis and shortening.

The anatomic structure of the forearm and elbow favors the production of Volkmann's contracture. The forearm and elbow are encased in a firm, resisting fascial envelope. Hemorrhage within this envelope cannot escape, and tremendous pressure results. Furthermore, in certain cases, the anatomic structure of the region contributes an added factor—the tendon of the biceps muscle passes downward and is inserted into the radius below. From this tendinous insertion springs a narrow fibrous band, the bicipital fascia, which crosses the elbow joint obliquely inward, fading out in the flexor muscles of the lower arm. The brachial artery passes directly beneath this fascia, which may be put under great tension due to intrinsic hemorrhage, edema, and swelling of the tissue. We may have tremendous hemorrhage with extravasation of blood into tissues in other parts of the body, and except for pressure hematoma in the popliteal region, a condition comparable to Volkmann's contracture does not develop. It is because of the peculiar anatomic structure described that pressure within the fascia sufficient to produce the condition is possible.

In the past, there has been considerable argument as to whether obstruction to venous outflow or impairment of arterial circulation was the cause. There is no question but that there is some obstruction to venous outflow. As pressure increases, due to extravasation of blood and serum with swelling of the soft structures, the veins, being more readily compressed, are affected first. There certainly is an unyielding fascia. As pressure is further increased, obstruction of arterial circulation occurs. This obstruction may be due either to actual arterial damage or to interruption of arterial flow from intrinsic pressure on the artery. In most instances, a combination of a few or all of these factors brings about a disintegration of the soft tissues due to pressure, hematoma, and anemia.

ACCURATE REDUCTION OF FRACTURE

The best preventive against the development of Volkmann's contracture is accurate reduction of the supracondylar fracture. On the Surgical Service at the Children's Hospital, Boston, in one hundred cases of this fracture, there has been but one which showed the picture of impending Volkmann's. Although these cases are encountered infrequently, in less skilled hands threatening Volkmann's will be met from time to time. Meyerding[4] states that in the Mayo series nearly 40 per cent of the fractures of the humerus, the majority of which were supracondylar fractures which had been treated by acute flexion, resulted in perfect union. Therefore, imperfect reduction of the supracondylar fracture may be a considerable factor in the production of ischemic contracture. If, in addition to the faulty reduction, the elbow is placed in too acute flexion, if too tight bandages or splints are applied, or if a hematoma forms in the antecubital space, tremendous pressure may be exerted upon the circulation with resulting paralysis and contracture. Following manipulation and reduction, the state of the circulation in the hand should be frequently observed by watching the color of the hand and the condition of the radial pulse. The position of the fragments should be checked by x-ray to be sure displacement has not occurred. The fracture becomes of secondary importance if there is any evidence of impaired circulation. Further immediate treatment should be directed toward relieving the pressure, extrinsic or intrinsic.

The mechanism in a supracondylar fracture which leads to Volkmann's contracture is as follows: The force which causes the fracture drives the condyles backward. The proximal fragment is displaced forward and downward, causing pressure against the soft tissues. Blood vessels and nerves may be compressed or torn. Blood which fills the antecubital space increases the pressure. Nerves and blood vessels may be injured directly, or

secondarily by the pressure of the hematoma. Due to the fascial envelope, the blood cannot escape. At times, tremendous intrinsic pressure results.
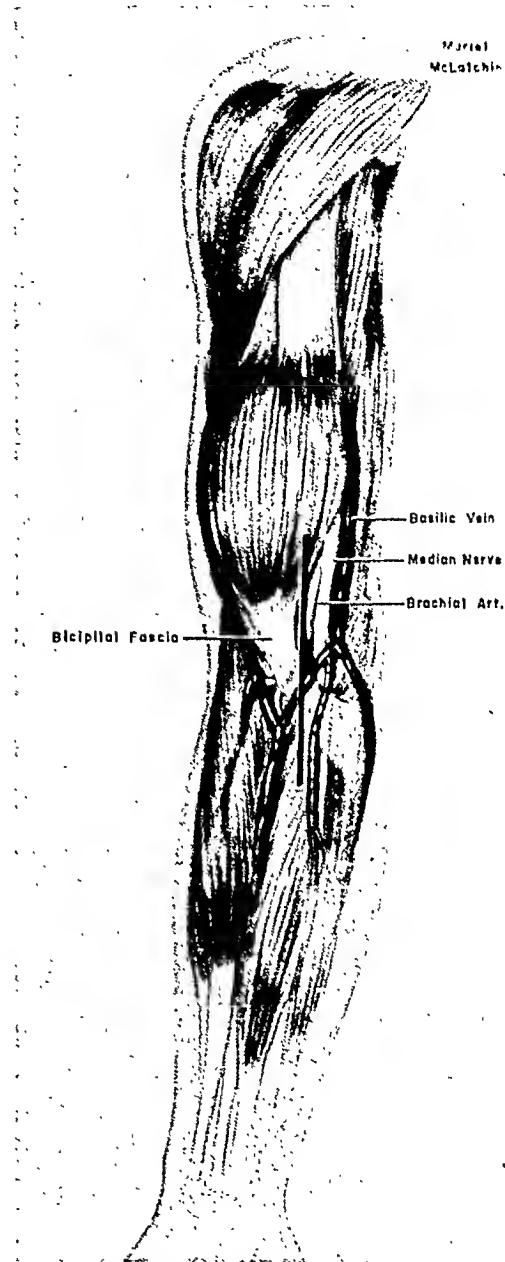
FIG. 1. Anatomy of elbow region demonstrating relationship of brachial artery and bicipital fascia. The heavy dark line indicates the location of fasciotomy incision.

It is not unusual to encounter a supracondylar fracture which presents an absent radial pulse. The majority of supracondylar fractures, treated immediately by accurate reduction and flexion of the elbow, give satisfactory results. In such cases, after reduction, the pulse returns. Manipulation should be gentle and repeated attempts at

reduction avoided. Too vigorous manipulation may cause extensive damage to soft tissues.

consultant should determine carefully the severity of the injury, the time interval between injury and consultation, and the
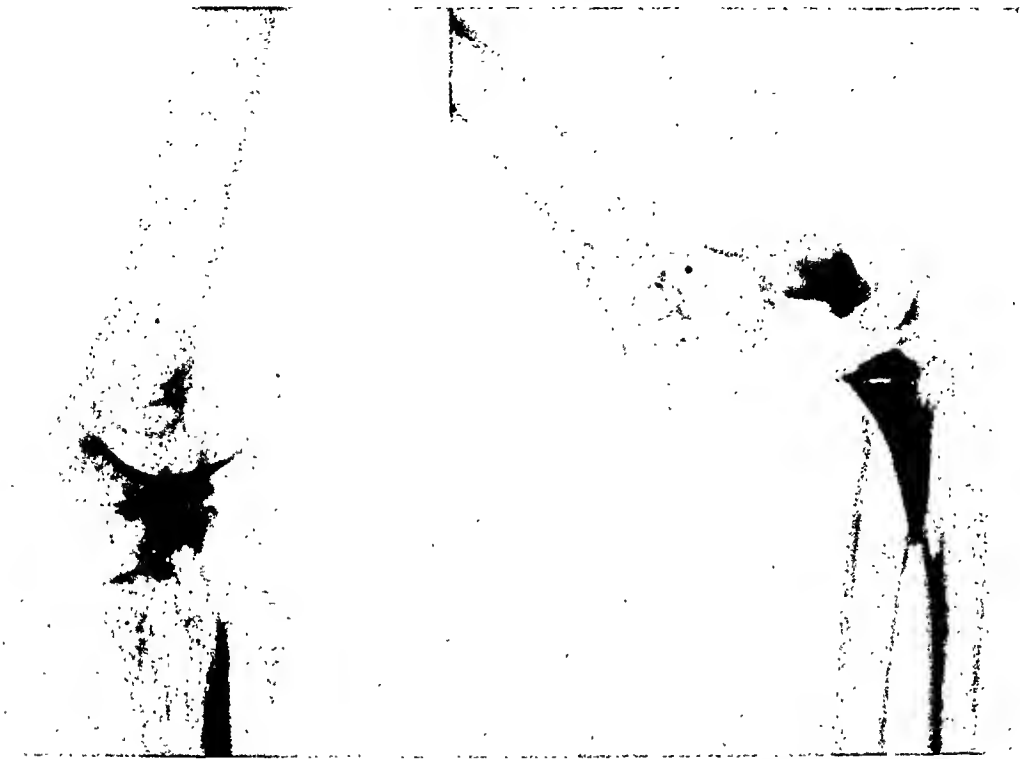
Fig. 2. Type of supracondylar fracture associated with impending Volkmann's.

The physician will encounter other cases in which, after reduction or attempted reduction, the radial pulse is still absent, or present only with the elbow extended or partially flexed. In the latter case, the arm should be elevated upon a pillow in a position compatible with maintaining circulation. The case should be carefully watched, reduction completed only at such time as the circulation allows.

Since supracondylar fractures showing complications may result in such a crippling deformity as Volkmann's contracture, the physician confronted with such a case should call someone in consultation to share responsibility. Otherwise, he may be blamed for a disability not the result of his treatment. Volkmann's does occur in the absence of splints or tight bandages. Previously it has been mentioned that hemophilia alone may cause Volkmann's. The danger of malpractice suits should always be remembered. Conversely, the

treatment given in order to protect both his own and the physician's interests.

There is a third group of cases which the physician will occasionally see which, in addition to the usual deformity of the fracture, shows evidence of a subfascial hematoma. The antecubital space is discolored, distended, tender, and painful. The swelling of the elbow increases and pain becomes more severe from hour to hour. Blebs of the skin may develop. The radial pulse is absent at the wrist. There is numbness of the hand which early is cyanotic, later cold and white.

Such a picture means that the intrinsic pressure due to a subfascial hematoma in the antecubital space has increased sufficiently to shut off the circulation at the elbow. The veins, being more readily compressed, are blocked first. Consequently, the hand becomes cyanotic due to interference of the venous outflow. As the pressure further increases, the more rigid

artery is compressed. As a result, the hand becomes white, cold, and numb. There is loss of motor power of the hand. The radial pulse at the wrist is absent.

FIG. 3. Arm showing swollen tense elbow with blebs of the skin.

Such a case is one of incipient or impending Volkmann's contracture. The treatment of the condition depends upon a number of factors. Accurate reduction usually results in a return of the radial pulse at the wrist and a disappearance of the other symptoms. Careful observation should follow. Of course, x-ray should be taken preceding and following manipulation, and position of the fragments should be checked with the appearance of any of the untoward signs mentioned above.

In certain cases the radial pulse is absent with the elbow in acute flexion, but present in semiflexion or extension. This loss of pulse may be due to the position of the arm or too tight a bandage. The arm should, under these conditions, be elevated upon a pillow, and the circulation observed. Bandages or splints which are too tight

should be replaced by others properly applied. I do not operate.

Then, there is the rare case in which the swollen painful elbow, the cold, white
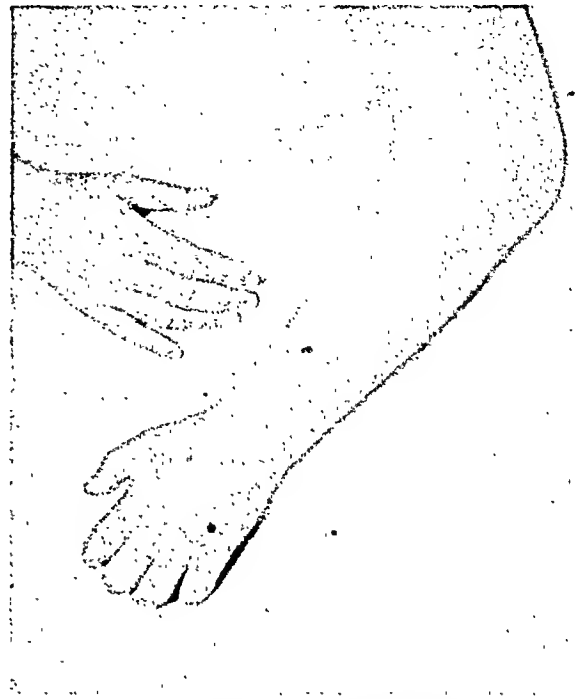
FIG. 4. Tense swollen arm showing evidence of obstruction of venous outflow. The lower arm and hand present a reddish-blue cyanosis.

numb hand and absent radial pulse persist after reduction of the fracture, with the elbow at any degree of flexion or extension. The circulation is completely shut off. There is pressure from the hematoma and infiltration of the tissues by blood. An anemia of the tissues results. The muscle cells are destroyed. Ischemic necrosis of the muscles and nerves takes place, with fibrosis and shortening.

The damage is done during the first twenty-four hours, certainly early. If the dreaded contracture is to be avoided, immediate treatment must be devoted to relieving the intrinsic pressure from the hematoma, disregarding the fracture. The treatment should be operative. It should be early. The operation is fasciotomy.

FASCIOTOMY

The operation of fasciotomy is performed as follows: An incision is made on the flexor aspect at the elbow over the hema-

toma, just medial to the biceps tendon. The fascia is opened widely. Muscle tissue and blood which have been under great tension will be liberated. In certain cases, the bicipital fascia will be found to be under great tension, exerting tremendous pressure upon the brachial artery which passes beneath it. This fascia is incised. The artery, vein, and nerve may be observed to ascertain the presence or absence of injury. The fascia is left open, the skin being loosely sutured. A posterior moulded plaster splint is applied and the arm is elevated upon a pillow.

As one becomes more accustomed to the anterior approach, it is often possible to reduce the fracture through the fasciotomy wound. Murphy[3] advocated early incision through an anterolateral ulnar approach with a delay of several days before reduction. In 1930, Meyerding[4] chose to enter the joint posteriorly, splitting the tendon of the triceps and, after washing out the blood clot from the antecubital space, to reduce the fracture by insertion of bone skid. At times, a beef bone screw was passed through the condyles into the shaft to maintain reduction. Later, in 1936, Meyerding[9] suggested the anterior approach, as described above. This approach leads directly to the hematoma in the antecubital space and affords an excellent opportunity both to observe the nerves and blood vessels and to reduce the fracture.

Three cases[10] of complete rupture of the brachial artery have been observed associated with fracture of the shaft of the humerus. The typical picture of impending Volkmann's presented. In each case, following fasciotomy, no atrophy of the flexor group of muscles with degeneration and fibrosis developed. These cases demonstrate that, with the brachial artery completely severed, the collateral circulation of the lower arm and elbow is adequate to prevent gangrene and to nourish the flexor group of muscles, provided this collateral circulation is given an opportunity to function. Such opportunity is furnished by release of pressure upon the circulation by fasciotomy.

It must be emphasized that the case presenting the typical picture of impending Volkmann's contracture requiring fasciotomy is extremely rare, but the fact that the condition is rare does not render it any less dangerous. If such a serious, but rare, situation is to avoid falling into disrepute, one must learn to evaluate carefully the signs and symptoms which require fasciotomy. Absent radial pulse at the wrist alone does not constitute an indication for operative interference. Congenital absence of the radial pulse has been noted.

A CASE OF RECENT FRACTURE WITH ABSENT RADIAL PULSE

A girl, 8 years of age, was seen one-half hour after she had fallen from the parallel bars, injuring her right elbow. A school nurse had placed the injured arm in a sling in the position of acute flexion. X-rays showed a supracondylar fracture with considerable deformity. The radial pulse was absent at the wrist. There was slight cyanosis of the hand. The patient volunteered the information that her hand felt numb. There was only moderate swelling of the elbow region. Pain was not marked. There was an area of ecchymosis in the antecubital region. The arm was changed from the position of acute flexion of the elbow to one of right-angled flexion. When seen twenty minutes later at the hospital, the numbness of the hand had disappeared. The hand was of normal color and warmth. The radial pulse was absent. The swelling and pain at the elbow had not increased. Following careful manipulation with excellent reduction under the fluoroscope, the radial pulse was still absent.

It was felt, in the presence of a hand of normal color and warmth without numbness, but with absent radial pulse, that an adequate blood supply was being maintained. The arm was elevated on a pillow at right-angled flexion and carefully observed. The picture did not change and on the eighth day after injury, under the fluoroscope, the arm was put up in acute flexion to complete reduction. Throughout the convalescence, the absent radial pulse was the only disturbing factor. It returned twenty-one days after injury, and the patient went on to complete and uneventful recovery.

This was a troublesome borderline case. Had there been a cold hand with numbness and color changes, as well as the absent pulse, evidence of impaired circulation would have constituted an indication for fasciotomy. Without these further changes, it was felt that the circulation must be getting through adequately in spite of the absent pulse.

Coldness, color changes, and numbness, with loss of motor power of the flexors, accompany each other and, together with absent radial pulse, constitute an indication for fasciotomy. This is especially true if there is, in addition, a painful, greatly swollen elbow with evidence of hematoma in the antecubital area.

In certain clinics, in order to avoid fasciotomy, the procedure of suspending the arm by overhead traction by means of a Kirschner wire through the olecranon is practiced. It is argued that in this way circulation is favored, and the traction maintains reduction of the fracture. Should this method of treatment fail to alleviate the situation, a fasciotomy could still be performed. This method is, I believe, capable of producing unfortunate results. It must be remembered that damage is done early in these cases of impending ·Volkmann's, certainly during the first few hours. Any procedure which does not assure a positive method for relieving the intrinsic pressure may waste valuable time. The operation of fasciotomy, performed early, relieves this pressure beyond the possibility of a doubt.

A case in point follows:[11]

A boy, 9 years of age, was admitted to the hospital. An hour before admission, he had fallen on his left arm. X-ray showed a typical supracondylar fracture with marked posterior displacement of the distal fragment. There was pain in the elbow, which was swollen; the hand was cold and anesthetic; there was slight cyanosis; and there was no radial pulse. The fracture was reduced under the fluoroscope; the radial pulse was still absent. Four hours after reduction, there was no radial pulse; the hand had become white, was cold and anes-

thetic. Pain in the elbow had increased with each hour, as had the swelling of the arm. An operation of fasciotomy was performed, and what appeared to be a thrombosis of the brachial artery was found, opposite the site of fracture. There was pulsation above the thrombosis but none below. The arm was placed on a pillow, and the radial pulse returned four days later, the warmth and color of the hand having improved the day following the operation.

The impending Volkmann's of the preceding case was due to direct injury to the circulation. A case giving the same picture, but due to pressure hematoma alone, follows:

A girl, 6 years of age, was admitted to the hospital. Seventeen hours before admission, she had fallen and sustained a supracondylar fracture of the right humerus. There was marked backward displacement of the distal fragment. The elbow was greatly swollen and painful, and there was swelling and ecchymosis in the antecubital area. The radial pulse was absent. The hand was cold, white, and numb. The fracture was carefully manipulated, and satisfactory reduction not obtained. Further efforts at reduction were not made because of the fear of increasing the already damaged circulation. The radial pulse was absent at all degrees of extension or flexion of the elbow. Neither was the appearance of the hand altered by extension of the lower arm. Accordingly, a fasciotomy was performed. A hematoma beneath the fascia, in the antecubital space, under considerable pressure, was found. The vessels appeared normal. With the release of the hematoma, the skin was loosely sutured, and the arm slightly elevated on a ring arm splint. The radial pulse returned three hours after operation. The warmth and normal color of the hand also returned, and the anesthesia disappeared. The further reduction of the fracture was carried out six days later by manipulation. The patient now has good functional use of the elbow. No Volkmann's contracture has occurred.

Ischemic paralysis of the leg simulating Volkmann's contracture, though rare, is occasionally observed. The following two cases[12] are of interest:

CASE I. A man, 45 years of age, entered the hospital December 6, 1931, having received a severe contusion of the right leg in the popliteal region by being crushed between the bumper of an automobile and the landing ledge of a building. There was considerable swelling and ecchymosis in the popliteal region. No pulsations were palpable below the femoral pulse in the groin. There was anesthesia of the foot and lower leg, and pain in the traumatized area. The right foot felt cold in contrast to the left. All pulsations were present on the left. X-ray was negative for fracture.

The foot was elevated on a pillow with a cradle and light over it. During the first week, the color of the foot and lower leg was poor. December 15, the tips of the toes were discolored, and by December 25, there was dry gangrene of the toes of the right foot. The circulation of the lower leg and foot had improved little, if any. He was discharged from the hospital January 29, 1932.

The patient was not seen again until November 27, 1932. During the interval, the gangrenous toes had amputated themselves. The foot was in rigid equinus. There was marked atrophy of all muscles below the knee so that the lower leg and foot looked mummified. There was no palpable circulation. The foot and lower leg were dusky in color; the temperature less than that of the left. However, sensation had returned in the foot.

November 28, 1932, tenotomy was performed on the tendo Achillis in order to bring the foot into a position compatible with walking. Dependency and activity of the leg were slowly prolonged until finally, after a period of disability of two years, the patient was able to return to his work as driver of a light laundry truck. There is still no palpable circulation below the groin, the appearance of the leg has changed but little, and it is problematical how long this man will be free from circulatory difficulty.

CASE II. A man 45 years of age entered the hospital March 12, 1935, having received a severe contusion of the left popliteal region by being crushed between the bumpers of two automobiles. There was tremendous ecchymosis, pain, and swelling of the upper leg and popliteal region. No pulsations were palpable below the groin. The left foot was cold, blanched, and partly anesthetic. (The right leg was normal.) X-ray showed a fracture of the upper end of the fibula in good position.

In view of our experience with arms under similar condition, exploration of the popliteal region was performed. The fascia was opened widely, releasing a large amount of blood clot under considerable pressure. The popliteal artery and vein were identified. Above a certain point there was pulsation in the artery; below, none. Although no thrombus was evident, there may have been one, or the condition was possibly only spastic. The fascia was left open, the skin being loosely closed.

In twenty-four hours, the anesthesia of the foot was diminished; there was a definite increase in warmth; and the color of the foot was better. In forty-eight hours, the anesthesia had entirely disappeared and there was a further improvement, pulsation in the dorsalis pedis and posterior tibial arteries was palpable. Dependency and activity were brought along slowly, and, seven weeks after injury, the patient was walking in the hospital on a foot which appeared to have adequate circulation for the activity his work on a bakery truck will require.

On June 5, 1935, he showed some edema below the knee. Pulsation in the dorsalis pedis (from behind forward) was of good volume. Color and temperature of the foot were normal. Sensation was normal throughout and there were no paralyses. He was able to walk and was incommoded only by stiffness in knee flexion, largely due to a thick scar unavoidably crossing the popliteal space.

Here we have two very similar cases. Both were men 45 years of age. Each received a severe crushing injury to the popliteal region. The first, treated simply by elevation and rest of the leg, resulted in a two years' disability and a leg with a very questionable circulation. In the second, where a fasciotomy gave the artery a chance to open up or the collateral circulation an opportunity to function, the patient, after seven weeks, had a leg upon which he could tolerate dependency for increasing periods of time and was in a few more weeks able to return to his work upon a leg worthy of his confidence.

The pavaex boot has intentionally not been used on either the arm or leg cases. In circulatory accidents which block a peripheral vessel, the pathology is confined to

the vessel itself. In impending Volkmann's contracture, there is, in addition to the direct vascular injury, the action of pressure. It is this latter factor which makes Volkmann's a distinct entity requiring treatment which will relieve the pressure quickly and surely. Should the pavaex machine fail to relieve the condition, valuable hours would be lost. It is difficult to understand how the pavaex boot could relieve the effects of a pressure hematoma; it is within reason to feel that it might aggravate the condition.

FIG. 5. Volkmann's contracture of the arm.

CONSERVATIVE TREATMENT OF VOLKMANN'S ISCHEMIC CONTRACTURE

Volkmann's ischemic contracture is a flexion deformity of the forearm, wrist, and hand, with or without paralysis, which produces the useless claw hand. The position of the fingers is characteristic, viz., the
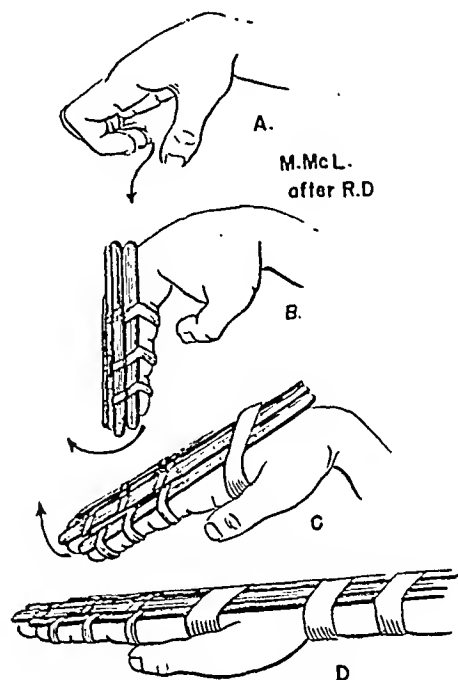
FIG. 6. Method of splinting (after Meyerding).

wrist is flexed, the metacarpophalangeal joints are hyperextended, and the interphalangeal joints are flexed. Upon acute flexion of the wrist, the fingers can be extended. The hand is pronated and the elbow semiflexed. Due to involvement of the pronator radii teres, supination of the forearm is impossible. The flexor group of muscles of the forearm is much wasted. The extensor muscles may remain intact. Joints and joint capsules may become involved. In long standing cases, there is atrophy of the bone as in infantile paralysis.

Attempts to straighten the wrist and fingers at the same time cause bands, which represent the normal flexor muscles, to appear in the forearm. These bands are due to a fibrosis of the flexor muscles which become cord-like and shortened following impairment of the circulation. Although an ischemic contracture simulating Volkmann's occurs in the leg, it is rare.

Every physician knows that muscles which have become fibrosed and contracted cannot be fully restored to their normal

function. There is no positive method of cure. Since there is certain to be some degree of permanent disability, any method

FIG. 7. A type of banjo splint for traction of fingers.

of treatment employed should be of conservative nature.

In determining appropriate treatment for Volkmann's ischemic contracture, consideration of the time element between injury and the beginning of treatment is important. Volkmann's contracture may develop within a few hours after injury. Not uncommonly it develops in the absence of treatment; it has developed in cases where no splints, bandages, or other forms of apparatus have been employed. The cases of contracture which have occured in hemophilia have been mentioned previously.

Usually, by the time a case of contracture is presented for treatment, the wrist is flexed, the metacarpophalangeal joints extended, and the phalanges acutely flexed. Fibrosis has already started in the flexor muscles of the forearm. Elbow motion is impaired and the hand is held in pronation. There are varying amounts of numbness in

the lower arm and hand dependent upon the nerves involved and the extent of involvement.

In these early cases, conservative treatment should be started at once. In the case of children, it is well to gain their confidence before beginning active treatment. This can be accomplished by starting with carefully conducted physiotherapy. Later they will coöperate with active motion, especially if their interest in improvement of motion of the stiff fingers is stimulated. General extension of the contracted muscles, following in general the methods of Sir Robert Jones,[2] should be employed.

An excellent way to accomplish the desired extension of the contracted fingers and wrist is one described by Meyerding.[9] With the wrist acutely flexed, it is possible to extend the fingers. A throat stick splint is fastened with adhesive strips to each contracted finger to maintain the extended position. Efforts are then directed toward actively extending the contracted metacarpophalangeal joints. When this has been accomplished, longer splints extending to the wrist are applied. The wrist is next exercised until it can be extended, and a splint extending to the elbow is employed. Such splints adequately padded and held in place by adhesive strips are as effective as more elaborate apparatus. At times, modifications such as the banjo splint may be used to advantage. This allows exercising of the fingers while extension of the wrist is being accomplished. Active motion is encouraged and is augmented by physiotherapy. In fact, little could be accomplished without intelligently employed physiotherapy.

A second group consists of those cases in which the injury occurred several months before. There is a typical claw hand. The contracted flexor muscles, resembling fibrotic cords, can be felt in the lower arm. The swelling has gone. The hand is held in pronation, while supination is often impossible. There may be limitation of motion of the elbow. Paralysis varying in amount from primary nerve injury or secondary

involvement in scar tissue exists. The radial pulse may still be absent. There may be atrophy of bone as well as of muscle.

tendon is divided. Beneath this will be found the tendons of the superficial group of flexor muscles. These tendons may be

FIG. 8. Tendon lengthening operation (after Meyerding).

Vicious union exists in about 40 per cent of the cases.

Whatever the form of treatment employed in these cases, results are apt to be less satisfactory than in the previous group. Conservative methods are also apt to prove best in this group. The stretching methods outlined above should be tried. If these fail, surgery may be resorted to in an effort to free tendons tied in the cicatrix.

A third group, in which years may have elapsed since the injury, presents problems which can at best be only partly alleviated. The rope-like contractures of the flexor muscles, the bone atrophy, nerve involvement, and impaired circulation make anything but a partial return of function impossible. There can be no complete cure. Conservative methods, although they should be tried, usually prove futile.

Some improvement may be obtained by tendon lengthening operations. The amount of benefit derived depends upon the extent of the damage. The greater the amount of fibrous scar tissue, the less can be accomplished. An incision is made through the skin of the wrist over the tendon of the palmaris longus muscle and parallel with it. The superficial fascia which envelops the

lengthened by making two oblique incisions three-fourths of the distance across and on opposite sides of the tendon, about 1 inch apart. The tendons are then lengthened by stretching with hemostats passed beneath them.

Nerves bound down in scar tissues may be liberated. Neurolysis is of special value when nerves are obviously involved in scar tissue of open lesions. But here again, the results vary directly with the amount of fibrosis found in the wrist.

In extreme cases, resection of bone may be employed if contracture is long standing and marked. However, removal of bone can be justified only in cases in which all other methods of treatment have failed. Forcible stretching of muscles and joints under anesthesia is not advised. Lowering of the origin of the flexor muscles is a valuable procedure at times. All these operative procedures produce best results when combined with the conservative methods previously outlined.

From the foregoing, it is evident that the prognosis of Volkmann's contracture depends upon a number of factors. Early, it depends upon the extent of damage to soft tissues, the length of time since injury,

type of apparatus used and how used, evidence of direct injury to nerves and blood vessels, evidence of amount of hemorrhage with pressure symptoms. Late, it depends upon the age of the patient, the amount of fibrosis and extent of contracture, the duration of the condition, and the amount of bony deformity. At best, it is a crippling condition which treatment can only partly cure. It is a condition which may be prevented by a very simple but effective procedure.

SUMMARY

Certain elbow injuries, notably supracondylar fractures, present themselves with a painful swollen elbow, an absent radial pulse, and a cold, anesthetic hand. If, after careful reduction, there is still diminished or absent radial pulse with loss of sensation of the hand, loss of voluntary motor power, and pain in the elbow increasing hour by hour, Volkmann's contracture is impending and immediate operation is necessary. The operation should be a fasciotomy. Appreciation of these facts is important not only in saving function, but also in lightening the burden of medicolegal responsibility that falls upon the doctors who treat these patients.

Once Volkmann's contracture has taken place, conservative methods of treatment by stretching, as described by Sir Robert Jones,[2] give best results. Any method of treatment must be augmented by intelligent use of physiotherapy. More severe cases may require surgery in addition.

CONCLUSIONS

1. Volkmann's contracture can be prevented.

2. Prevention of Volkmann's contracture is more important than its treatment.

3. Volkmann's contracture does occur in the absence of splints or tight bandages.

4. Volkmann's contracture is caused in certain cases by interruption of circulation.

5. This interruption may be due to direct injury to the vessels themselves.

6. This interruption may be due to intrinsic pressure upon the circulation caused by hemorrhage within the fascial envelope.

7. The collateral circulation of the elbow is sufficient if given an opportunity to function.

8. The operation of fasciotomy, performed early, gives this opportunity.

9. Once Volkmann's contracture has taken place, conservative treatment is indicated.

10. No method of treatment is certain of cure.

11. Muscles which have become fibrosed and contracted cannot be fully restored.

12. Volkmann's ischemic contracture may occur due to injury or hemophilia in the absence of any treatment.

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Surgical emphysema or the infiltration of the cellular tissues with air may result from laceration of lung adherent to the chest wall.

BRACHIAL BIRTH PALSY

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IT seems wise to state clearly at the beginning of this paper that I do not feel that we have yet arrived at the final solution of the problem of brachial birth palsy. Some of the ideas I shall express are somewhat at variance with those generally set forth. They have arisen in the course of several years special interest in and study of the problem, but I am sure they do not represent a solution that is entirely satisfactory to me. Nevertheless the first step in a solution is often the process of obtaining a clear view of the relative values of the various elements involved in the problem. This article will attempt this as I see it.

Etiology. The primary etiology is injury, of varying degree and extent, to the nerve roots entering into the cords of the brachial plexus or to the cords themselves. This injury results from traction on the cords of the plexus during a difficult delivery. The predisposing cause is either a breech presentation in which traction is applied to deliver the after-coming head or a head delivery in which a shoulder is caught behind the pubes and traction is applied to the head to dislodge it. In either case the head and shoulder are separated widely and it is this which places the strain on the plexus. Since the fifth and sixth cervical nerves are the highest up and therefore furthest from the center of rotation, they are stretched through a longer arc and are the first to give way. It is the muscles supplied by these two nerves which show the greatest loss of function in the majority of cases.

Primary Pathology. From the etiology we have described it appears that the primary pathology is in the cervical plexus. Some confusion has arisen since there are other forms of obstetrical trauma to the shoulder, such as slipped epiphysis, dislocation of the shoulder and fracture of the humerus or clavicle. These, however, are not obstetrical paralysis. In paralysis there is injury to the plexus, as has been made clear by dissection and exploration of numerous cases, which leave no doubt. The pathology in the plexus occurs in varying degree. There may be little direct injury to the plexus cords but a perineural hemorrhage from the surrounding soft tissues may cause pressure on the nerves, resulting in a physiologic block. The fate of the nerves will largely depend on what happens to this hemorrhage. If it is absorbed the block is removed and recovery will take place. If it cicatrizes and contracts the pressure remains permanent.

In somewhat more severe cases there may be intraneural hemorrhage which may have the same fate as the perineural. Still more severe cases result in partial tearing of the nerve fibers composing the cord. Secondary to this will be the formation of neuromata with resulting permanent nerve blockage.

The most severe injury is the complete avulsion of the nerve roots from the spinal cord or complete rupture of the cords of the plexus. As these pathologic processes vary in degree they also vary in extent. However, the severity of the injury and the extent tend to be in direct proportion—that is, the most severe injury is usually of the greatest extent.

Secondary Pathology. The primary pathologic changes in the nerves lead sooner or later to certain changes developing as a result of the nerve injury. This secondary pathology in reality furnishes the physical findings characteristic of

brachial birth palsy, and it is these secondary changes with which the orthopedist has most frequently to deal.

First to appear among the secondary pathologic changes is muscle paralysis dependent directly on the nerve injury. The muscles affected are of course those supplied by the injured nerve. The paralysis is flaccid, being of the peripheral type and is accompanied by atrophy of the paralyzed muscles. It affects various groups depending on the injured nerves. This paralysis of groups of muscles leads to unbalanced muscle action with contractures and deformities resulting. These contractures in turn lead to distortions and deformities in the joints, particularly the shoulder, where subluxation is common, and in the elbow, where a displacement of the radial head is often seen.

Among the secondary pathologic changes are changes in the bones of the affected arm which are shorter and frequently smaller. These changes are usually ascribed to lack of use, but we are tempted to believe that they are a direct trophic effect of the nerve injury. We have noted quite regularly that the appearance of the epiphyses in the affected arm is delayed as compared with those of the unaffected arm. Furthermore, there is a distinct lag in their growth. Except in the very severe cases there is little demineralization but rather a delayed growth of bone of fairly normal structure. This is particularly true of the moderate cases where there is often vigorous though, of course, impaired use of the affected arm. These considerations make us doubt whether disuse is so much a factor as the injury to the nerves.

Physical Findings. We have already mentioned that it is the secondary pathologic changes which lead to the characteristic physical findings on which we base our diagnosis and which furnish indications for treatment. In the very earliest cases there is practically only one finding and that is nonfunction of the affected member. There may be swelling in the supraclavicular space and pressure there or attempted passive motion of the arm will elicit evidence of pain. The findings seen later develop slowly and differentiate the cases into different types. These types are as follows:

1. Severe or total type.
2. Moderate type.
    (*a*) Upper arm (Erb's paralysis)
    (*b*) Lower arm (Klumpke's paralysis)
3. Slight type.

Of course there is no sharp line of demarcation between these types and there is very frequently a combination of the upper arm and lower arm types without a total paralysis.

Severe Type. The physical findings in this case are primarily a flail arm hanging in the neutral position. All the muscles being affected, there is no distortion. The shoulder joint is usually lax and subluxated downward due to the weight of the arm, which drags on the capsule and the toneless muscles and acts on the shoulder joint. Atrophy of the muscles is marked and involves all groups. The skin is glazed, thin, usually somewhat reddened from the sluggish circulation. There is very little contraction or deformity, the only one commonly seen being flexion of the midphalangeal joints seen in the *main à griffe* following median nerve injury. The elbow joint has usually lost the carrying angle and is straighter than normal. X-ray shows the bone smaller, usually demineralized, and with very thin cortex. Fortunately these severe total cases are rare.

Moderate Type. By far the majority of cases fall into this class. Whether a case is of the upper arm or lower arm or mixed type depends solely on the extent of the injury. The classical description in these moderate cases is the arm held in the position of an adducted and internally rotated shoulder joint, slightly flexed wrist and fingers. The muscles affected are the external rotators, shoulder abductors, supinators and extensors. These are all supplied by the branches of the fifth and sixth cervical nerves.

Skin and other trophic changes are not marked in this type except that the arm, especially the upper arm, is shorter than

FIG. 1. Delayed epiphyseal development on the affected arm in brachial palsy. The scapula is also smaller.

the unaffected side. This shortening is actual, not apparent, and, as we have already mentioned, comes from the lag in epiphyseal development. The disability in these moderate cases arises from the fact that the weakness of the abductors and external rotators makes it impossible to swing the arm overhand or to reach the top of the head. Even reaching the face is very awkward, usually being accomplished by elevating the elbow high in the frontal plane of the body and bringing the hand down to the face. This is entirely due to the inability to rotate the humerus externally enough to keep the hand away from the body. The deltoid is practically always affected in birth palsy of the upper arm type, but it is not completely nor evenly paralyzed.

If one observes the shoulder motion in these moderate cases it is found that the anterior portion of the deltoid is usually of good power, while the posterior portion arising from the spine of the scapula is paralyzed. In the normal shoulder the deltoid acts in two portions separately—the anterior or clavicular portion elevating the elbow forward in the sagittal plane, while the posterior portion is relaxed, taking no part in this motion. In brachial palsy this motion is usually preserved. Direct abduction laterally from the body, however, is

usually lost, apparently because of the loss of the posterior position of the deltoid which acts strongly in this motion. The

FIG. 2. Improved abduction and external rotation splint. The bar prevents forward movement of the elbow. The humeral head is held forward in the glenoid.

posterior portion also has a secondary action as an external rotator of the humerus. These varied actions of the deltoid should be kept clearly in mind as they have an important relation to the treatment.

Associated with and following the internal rotation contractures there is a tendency to develop a posterior subluxation of the humeral head. This is accentuated by the paralysis of the infraspinatus and teres minor which reinforce the posterior wall of the capsule of the shoulder joint. This subluxation backward still further complicates matters by rendering the fulcrum against the glenoid cavity very unstable. In the moderate cases there is frequently some flexion contracture at the elbow joint. Occasionally the head of the radius is dislocated upward from its normal position. A moderate pronation contracture is also common. These cases of moderate severity are much more frequently seen than the severe.

Treatment. Every baby delivered, especially where any difficulty has been experienced, should be observed carefully for any evidence of obstetrical paralysis. The evidences are not slow in appearing and any inequality of use in the two arms, particu-

larly if there is apparent pain on passive motion of one arm, should lead to a suspicion of nerve injury. The injury may

tive, hence his judgment is bound to be biased.

One must admit that since the primary

Fig. 3. Models showing method of deltoid transplant. A, portion of deltoid freed from acromion. B, portion of deltoid inserted into spine of scapula.

be mild and the recovery rapid but it should not be overlooked. The first indication to be met in treatment is to remove the stretch from the nerve cords. This is accomplished by elevating the shoulder so that it will approach the ear on the same side and fixing it in that position. This is usually accomplished by abducting and externally rotating the shoulder and flexing the elbow so the forearm is above the head. In this position there is the greatest possible "slack" in the cords of the cervical plexus. This position may be retained in many ways. A strip of aluminum extending from the waist to the elbow and bandaged on is effective if care is taken in handling the infant. Fastening the wrist and hand to the head of the crib is also effective, while the infant is lying on its back, but the arm must not be allowed to dangle when the child is taken up for nursing or bathing. Massage, especially in the region of the injury, is contraindicated. The only surgery at all to be considered in the early cases is exploration and repair of the cervical plexus. Personally I do not feel competent to pass judgment on this procedure since I have never had the opportunity to follow up the cases. The orthopedic surgeon sees only those cases on whom the exploration and repair have not been effec-

pathology is found in the cervical plexus it seems logical to attack it fundamentally. Yet the surgery of nerves is so uncertain even in the most skilful of hands that only those trained in its finer details should attempt it. In such hands an attempt at repair seems the most fundamental attack on the problem, but ordinarily the cases are not seen at the time when such repair would be most effective. Other measures must be used in most instances.

The first indication to be met is the prevention of deformity, particularly the contracture in adduction and internal rotation. This is usually accomplished by the use of some form of brace. The brace to be thoroughly effective should hold the arm externally rotated and abducted laterally. The external rotation is easily controlled but to keep the shoulder abducted directly laterally is not so easy. There is always a tendency for the elbow to be carried forward and if this occurs it is difficult to prevent posterior subluxation of the humeral head from developing. Our brace-maker at the Shriner's Hospital has worked out a brace which is more effective in holding the shoulder forward than those ordinarily used. The use of a brace does more than prevent deformity as we see it. After a period of brace support and

immobilization there develops a certain amount of stiffness in the shoulder joint due, we believe, to general contracture and physis and we have seen several crushed or slipped epiphyses from manipulation. If there is a beginning subluxation, at-

FIG. 4. K. S. A, in 1933, showing limitation of external rotation. B and C, in 1938, five years after deltoid transplant. External rotation and abduction improved.

fibrosis of the capsule. This serves partially to fix the joint in a favorable position and a good functional result is obtained though not always a brilliant cosmetic result. At any rate our most successful cases from a functional standpoint have been those in which this tightening process—by no means an ankylosis—has occurred. It does not occur if the humeral head is allowed to slip backward in the glenoid cavity.

To sum up, in our opinion the use of a brace is primarily to prevent the posterior slipping of the humeral head and this it must do. In cases when contractures have developed the question arises as to how they are to be dealt with. As has been said, the contracture most frequently developed is that of the internal rotators, particularly the subscapularis and the pectoralis. In our experience if the contracture is of more than minor degree it is practically impossible to release it by manual stretching. The leverage is such that the force is exerted principally on the humeral epi-

tempted stretching tends to increase it rather than elongate the contracture. In these cases the most direct and effective attack is the operation devised by Sever in which the tendon of the subscapularis is divided. After the release of the contracture the arm is retained in the externally rotated and abducted position until healing is well completed, when exercises are begun. It is necessary following this operation that the head of the humerus should be held well forward in the glenoid cavity to provide the maximum release of the contracture. The Kleinberg operation frees the periosteum from the upper portion of the periosteum and rotates the bone inside the periosteal tube into a position of external rotation.

Putti, Hibbs and others have performed osteotomies of the humerus at various levels and have rotated the lower fragment to outward rotation. These operations fall into two classes. The Sever operation releases the contracture while the others

change the relation of the bone to the contracted internal rotators, thus relieving the effect of the contracture. The Sever

intact acromial and clavicular division of the deltoid into an external rotator by shifting its origin backward to the spine of

Fig. 5. J. R. A and B, in 1933. Marked limitation of lateral abduction and external rotation. C and D, in 1938, five years after deltoid transplant. Increase in motion. No subluxation.

operation is effective where subluxation of the head has not occurred, particularly if the head is retained well forward in the glenoid and if the posterior portion of the capsule is firm and strong. Otherwise the contracture may recur to some extent. The Kleinberg operation or one of the osteotomies of the shaft is more effective where subluxation of the humeral head with accompanying stretching of the posterior capsule has taken place, and, of course, contracture does not recur since it has already taken place.

Another line of attack is by attempting to restore muscle balance between the internal and external rotators as exemplified in an operation devised by l'Episcopo and one devised by the author. L'Episcopo, after relieving the internal rotation contracture, transplants the tendon of the teres major to the outer side of the humerus, thus transforming it from an internal to an external rotator. The author attempts to transform a portion of the

the scapula as far as possible, to replace the paralyzed posterior deltoid. The idea originated from observation of a "freak" case of obstetrical paralysis in which the posterior portion of the deltoid had been spared while the anterior portion was paralyzed. In other words in this particular case the usual findings were reversed so far as the deltoid muscle was concerned. This case showed none of the internal rotation contracture and no subluxation of the humeral head. Lateral abduction was lacking and forward abduction was limited to about 45 degrees and was accomplished by the pectoralis major. However, on the whole this case seemed to us to have less disability than the usual type we have described. Certainly bringing the hand to the face and mouth was much less awkward than usual. The operation we have been using was an attempt to imitate this case just described. The operation has been done on fourteen patients from 1931 until the present time. Recently—within the

past few weeks—six of the earlier cases were reëxamined critically and the results studied. It was this critical study which lead to the remark in the opening paragraph of this paper.

We have not classified the results as good, fair, or bad, since this seems to us rather meaningless or at least indefinite, but we have tried to make a detailed study of the effect of the transplant and what it has and has not done. In all the cases, if there was an internal rotation contracture present, it was relieved by a Sever operation before the deltoid transplant was done. The transplant has remained attached in its new position and has retained its power of contraction in all cases except one in which the patient was too young. In our later cases we have been taking a larger portion of muscle for the transplant. This necessitates sacrificing some power in the anterior deltoid but the remaining portion, supplemented by the pectoralis major, has been able to abduct the arm forward. The transplant has not increased the lateral abduction function of the shoulder as we hoped it might. In three cases we have supplemented the operation by transplanting a portion of the trapezius into the greater tuberosity of the humerus, as described by Haas for paralysis of the deltoid. In one case this gave complete lateral abduction against gravity, in another, a smaller increase of function, while the third is too recent to be sure of. The transplant acts as an external rotator when the shoulder is abducted forward or only slightly abducted laterally from the body. This external rotation is not with the full power of a normal shoulder, but is sufficient to permit much easier reaching of the hand to the face. The deltoid transplant will not correct subluxation of the humeral head from the glenoid. As a matter of fact any marked degree of subluxation will decrease the effective action of the transplant because of the instability of the fulcrum afforded by the joint. As we see it, this instability of the shoulder joint is the main difficulty in overcoming the effects of birth

palsy and is one which we have not yet solved to our complete satisfaction. We believe that the deltoid transplant after release of internal rotation contractures does much to prevent their recurrence, but this point is difficult to prove definitely. We feel that a subluxation of the shoulder joint is at least a relative contraindication to the deltoid transplant operation.

SUMMARY

We stated at the beginning that we hoped to set out the problem of brachial birth palsy even though we have reached no completely satisfactory solution. As we see it, then, it comes down to this:

At the time the orthopedist usually sees the patient the primary pathology is beyond redemption, and he has therefore to concern himself with either prevention (if possible) or correction of secondary pathology. To my mind the most important element in this is the subluxation of the shoulder joint rather than the contracture, though the two go hand in hand. The contracture can easily be dealt with, but if there is also subluxation of the humeral head there is still a very unstable base for the available muscle power to act upon.

In the earlier cases the prevention of these secondary pathologic changes is in order. This is usually done by a brace holding the shoulder abducted to a right angle (not beyond) and externally rotated. It must be borne in mind, however, that a splint has no volition of its own and it is up to the surgeon to see that it is doing what he wants it to. We would add that the splint must be so designed and fitted that it not only holds the arm in abduction and external rotation but also holds the humeral head forward and in close contact with the glenoid. Otherwise it will not prevent deformity.

If prevention measures do not achieve the desired result, then operative measures are in order. As to the choice of operation, it will vary with the individual cases. In general we feel that the Sever operation releasing the contracture gives better

results when there is no subluxation of the joint. If there is subluxation we feel that one of the osteotomies or the Kleinberg operation which realizes the position of the humerus without disturbing the contracture are preferable.

Transplantation of muscle about the shoulder is a tempting field but there are many difficulties involved. Deformity must be corrected first and a stable joint provided before it can be effective.

So far as our own operation is concerned, we have had disappointments—perhaps because we hoped for too much—but few failures. We still feel that all the cases except two have been improved, though not to the extent we had hoped. We still believe that with more experience the technique can be improved to the point where it will be more effective. It is pondering over disappointments that gives one experience.

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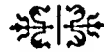
THE TREATMENT AND RESULTS OF 870 SEVERED TENDONS AND 57 SEVERED NERVES OF THE HAND AND FOREARM

(IN 362 PATIENTS)*†

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INTRODUCTION

INJURIES to the hand and forearm of a working man may mean his ruination from an economic standpoint. In
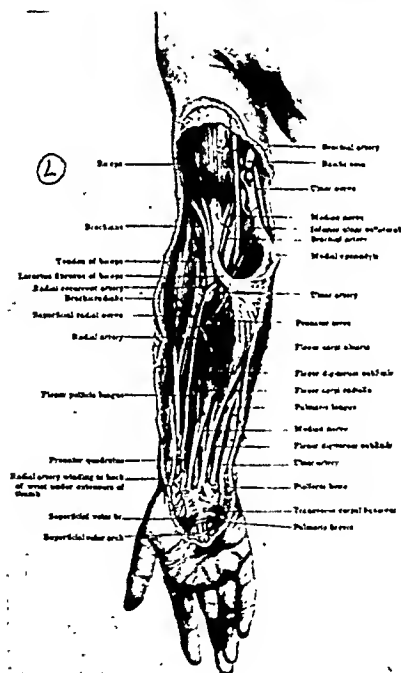
Fig. 1. Illustrating some of the complicated anatomy of forearm and wrist. (After Sobotta.)

spite of this many physicians and surgeons, and even the Compensation Commission in the Department of Labor of the State of New York and other states, treat such injuries with inappropriate consideration. Tendon and nerve injuries to these areas, if improperly treated, will mean financial ruin for the man who earns his living by the skill of his hands. A hand injury can exact considerably more care and skill from a surgeon and cause far greater disability to a working man than any hernia or fracture. Many renowned and experienced surgeons are therefore discouraged from treating this type of case because of its drudgery, its necessarily great time consumption and its most inadequate remuneration, which is out of all proportion to that of all other traumatic surgery and its own intrinsic importance to the patient. The repair work then falls to the lot of the younger and more inexperienced surgeon, often at the expense of the disabled laborer.

To quote Dr. Allen Kanavel, "The hand of the working man is his most valuable asset. Without it, life becomes a burden."

A survey of the literature on tendon injuries of the hand reveals a remarkable scarcity in the reporting of rates of infection and follow-up results as compared with the number of articles describing new techniques. In presenting this paper, I shall endeavor to show our success, our errors in judgment, our rate of infections, the various causes of these injuries and infections, and our end results.

Eight hundred seventy severed tendons and fifty-seven severed nerves of the hand, wrist and forearm were treated by the surgeons of St. Vincent's Hospital during the fifteen years prior to July 1938. The 870 severed tendons occurred in 344 patients, while the fifty-seven severed nerves were found in forty-nine patients. Of these patients thirty-one had both tendons and nerves severed and eighteen had only nerves injured. In all, there were 362 cases treated.

CAUSES

Of the 349 "known" causes of the injuries in this series of cases broken glass was the predominant offending agent. This glass came principally from broken bottles and drinking receptacles and less frequently by projecting hands through windows, glass doors and auto windshields.

At St. Vincent's Hospital, which serves a large neighboring commercial and industrial area, and which is situated in the Greenwich Village section of New York, well known for its eccentricities and bacchian pursuits during Prohibition, the predominating causative factors of the injuries are vastly different from those found in other hospitals, which serve popu-

TABLE I
KNOWN "CAUSES" OF INJURIES

	Dorsum of Hand and Fingers	Palm of Hand and Fingers	Dorsum of Wrist	Volar of Wrist	Dorsum Fore-arm	Flexor Fore-arm	Totals
Machines and rotating saws..................	39	26	2	2	0	1	70
Falling sharp objects.......................	14	5	0	4	3	0	26
Steel hooks...............................	2	0	0	0	0	0	2
Windows and windshields...................	25	11	6	35	2	4	83
Broken glass and bottles...................	31	43	6	20	0	0	100
Knives (accident).........................	14	15	0	1	1	0	31
Knives (assault)..........................	2	4	4	6	2	3	21
Bullet wounds............................	1	1	0	0	0	0	2
Auto accidents (metal)....................	2	0	0	0	0	0	2
Water faucets (agate).....................	0	3	0	0	0	0	3
Revolving fans (electric-organ)............	0	3	0	0	0	0	3
Burns (electric-third degree)..............	2	0	0	0	0	0	2
Exploding bottles (vichy and water)........	0	0	0	2	0	1	3
Ball (trauma)............................	2	0	0	0	0	0	2
Totals..................................	133	111	18	70	8	9	349
Total Compensation Injuries...............	62	36	2	10	3	2	115
Glass of all Types.......................	56	54	12	57	2	5	186

As one studied these records embracing a period of fifteen years, it was interesting to note the ever diminishing number of injuries caused by broken windshields and windows of automobiles, in spite of the ever increasing number of automobiles on the streets of New York. This improvement first manifested itself about five years ago when legislation prohibited the use of any but "shatter-proof" glass in the construction of automobile windshields in this state. In the 186 injuries caused by glass trauma to the volar surface of the wrist, or either of the surfaces of the hand and fingers occurred in about equal frequency. (Table I.)

lations of other foreign racial strains, and other types of industry with different forms of machinery and occupational hazards.

At St. Vincent's Hospital the most frequent cause of tendon trauma is broken glass (53 per cent); the next most frequent classification consists of compensation injuries (36 per cent) caused by printing presses, dye cutters, circular saws and other miscellaneous forms of factory machinery and hazards. The third cause in order of frequency is injury by knife wound, the accidental wounds being more frequent than the wounds from assault. Several cases were those of attempted suicide.

Compensation injuries occur almost twice as frequently on the dorsum of the hand and fingers as on the palm of the hand,

sites:—In order of frequency they are (1) the palmar surface of the proximal row of phalanges of all ten digits; (2) the volar
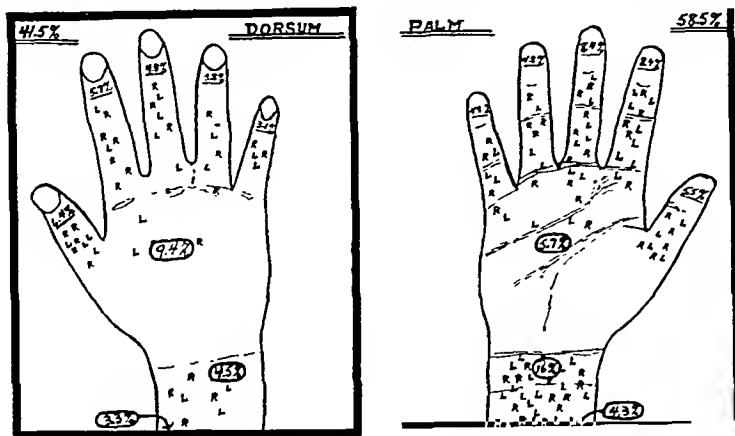
FIG. 2. Location of site of injury.

which is second in incidence. The dorsum of the wrist was injured but seldom with this type of trauma. These injuries are frequently jagged or crushing wounds which cause considerable maceration or evisceration of tissue and are difficult to repair. Associated with these were many fractures and amputations.

Broken windows usually severed the tendons on the volar surface of the wrist or the dorsum of the hand, while broken bottles and drinking vessels had a predisposition to lacerate the tendons in the palms of the fingers and hand and less often their dorsal surfaces.

Numerous infrequent miscellaneous accidental causes were recorded such as exploding vichy bottles, cracked porcelain water faucets, revolving fans (electric, auto and organ), bullet wounds, baseball injuries and third degree electric burns.

The type of weapon inflicting the injury has by its very nature an influence on the site, the severity and the ultimate outcome of the injury. The site of laceration in turn has a direct relation with the time when the injury must be sutured, how it is to be repaired, and its ultimate probable outcome.

SITE OF THE LACERATION

Our records show a preponderance of the injuries occurring in three definite

surface of the wrist; and (3) the dorsum of the hand.

TABLE II

"SITE" OF 391 LACERATIONS IN 344 CASES OF TENDON INJURY

	Flexor Surface	Extensor Surface	Totals	Percentage
Forearm.......	17	13	30	7.6
Wrist.........	64	18	82	20.8
Hand.........	22	37	59	15.3
Digit I........	21	27	48	12.2
Digit II.......	33	22	55	13.8
Digit III......	33	19	52	13.2
Digit IV......	19	15	34	8.7
Digit V.......	19	12	31	7.8
Totals.......	228	163	391	100

As many of the patients suffered multiple lacerations of the fingers and the palm of the hand, there was a total of 391 wounds in which tendons were severed in the 344 cases. The flexor surfaces were involved in 58.5 per cent and the extensor surfaces in 41.5 per cent. (Tables II and III.)

The wrist surfaces were injured in 21 per cent of the cases, the forearm in 7.5 per cent, and the hand in 15 per cent of the cases. The remaining 56 per cent of the wounds were located in the dorsal and palmar surfaces of the fingers. The index and middle fingers were the most fre-

quently traumatized, the thumb less frequently and the ring and little fingers but seldom in comparison. The most frequent site of trauma was the volar surface of the wrist, which was injured almost twice as often as any other area, and this

TABLE III

"SITE" OF 319 WOUNDS IN 344 CASES OF TENDON LACERATIONS

	No.	Percentage
Flexor Surface	230	58.5
Extensor Surface	163	41.5
Forearm	30	7.6
Wrist	82	20.8
Hand	59	15.3
Fingers	220	55.7

	Percentage
"Flexor" Surface of Forearm	4.3
"Flexor" Surface of Wrist (most frequent)	16.3
"Flexor" Surface of Hand	5.7
"Flexor" Surface of Digit I	5.5
"Flexor" Surface of Digit II	8.4
"Flexor" Surface of Digit III	8.4
"Flexor" Surface of Digit IV	4.8
"Flexor" Surface of Digit V	4.8
"Extensor" Surface of Forearm	3.3
"Extensor" Surface of Wrist	4.5
"Extensor" Surface of Hand (second in frequency)	9.4
"Extensor" Surface of Digit I	6.4
"Extensor" Surface of Digit II	5.7
"Extensor" Surface of Digit III	4.8
"Extensor" Surface of Digit IV	3.8
"Extensor" Surface of Digit V	3.1

area was followed in order by the dorsum of the hand and the dorsum of the thumb. (Table III.)

The possibility of nerve injury when wounds are in their neighboring tissues must always be borne in mind and tested for. Lacerations at the wrist were usually severe in extent and frequently severed four or more tendons and one or more nerves. It is advisable for the surgeon who is doing traumatic surgery frequently to refresh his memory of the topography involved.

TYPE OF TENDONS INVOLVED

In this series of cases more than half (56 per cent) of the tendons were severed in the digits, their flexor tendons being involved one and one-half times more frequently than the extensor tendons.

Sixty-three per cent were flexors (549 tendons) and 37 per cent were extensors (321 tendons). This incidence varies in hospitals in different sections of the city, as at Harlem Hospital the flexor tendons are severed in about 75 per cent of the cases, while another hospital reports 72 per cent flexors in its series of cases.

TABLE IV
ANALYSIS OF TYPES OF TENDONS

	Percentage
800 of the 870 severed tendons were repaired	92
549 of the 870 severed tendons were flexors	63.1
506 of the 800 repaired tendons were flexors	63.3
321 of the 870 severed tendons were extensors	36.9
294 of the 800 repaired tendons were extensors	36.7
43 of the 549 flexor tendons were not repaired	7.8
29 of the 321 extensor tendons were not repaired	9

24 per cent of severed tendons were wrist tendons
76 per cent of severed tendons were digital tendons
Twice as many digital flexors were severed than digital extensors (except thumb).
Five times as many wrist flexors were severed than wrist extensors.
The flexor and extensor tendons of thumb were injured in equal amount.
The tendons of digits IV and V were injured less frequently than all others.

The high incidence of severed digital tendons in the palm of the hand and fingers with the resultant injury to their tendon sheaths prognosticated results which must be unfavorable, for the flexor tendons when injured have been reported by all observers to give the most unfavorable functional and economic results. Five times as many flexors of the wrist were severed as were wrist extensors. The tendons of digits IV and V were injured much less frequently than those of the other digits. As will be seen later when I discuss func-

SEX AND SIDE INCIDENCE

TABLE V
SIDE AND SEX INCIDENCE

Tendons (344 cases)
{
  311 Males (803 Tendons) { Right Side—156 / Left Side—158 / Bilateral—3
  33 Females (67 Tendons) { Right Side—14 / Left Side—19
}

No single causative factor (broken glass, broken windows, and compensation injuries) had a predisposition to injure any one side of the body.

tional results our statistics vary little from those of the few authors who have published their end results.

Of the cases 90 per cent were males and only 9.6 per cent were female. No single causative factor had a predisposition to injure any one side of the body. The injuries were practically equally distributed between the two upper limbs. The left side was injured slightly more frequently than the right side when the cases of tendon injury were analyzed, but the opposite was true with reference to the severed nerves. There is but little difference in the frequency of injuries of this nature to one particular side of the body.

COMPLICATIONS

The most important complication of tendon injury and one which frequently spells disaster is "infection" of the wound. "Crushing injuries" with resultant bursting lacerations and bone fractures or amputations likewise frequently foretell unsatisfactory end results. Evulsion of an overlying area of "full thickness of skin" usually necessitates extensive surgery for several weeks, while grafting full thicknesses of skin from other body surfaces. Skin grafting when necessary should be done as soon as possible and only "full thickness" pedicle grafts containing some subcutaneous fat should be used. "Nerve injuries" especially at the level of the wrist will usually delay the optimum result to a year or more after the injury. "Adhesions" to neighboring tendons, their own sheaths, the areolar tissue, or to the

TABLE VI
COMPLICATIONS OF TENDON INJURIES

1. Infected and badly soiled wounds
2. Time when surgeon first sees case
3. Crushing injury to soft tissues and bone
4. Evulsion of large area of skin (full thickness)
5. Compound and other fractures of bones
6. Traumatic amputations
7. Nerve injuries
8. Postoperative infections
9. Discharging wounds (foreign body reactions)
10. Location of laceration
11. Coöperation of patient during efforts at rehabilitation

scar of the skin wound will all mitigate against attaining normalcy. Injuries to larger blood vessels, joints and bones all
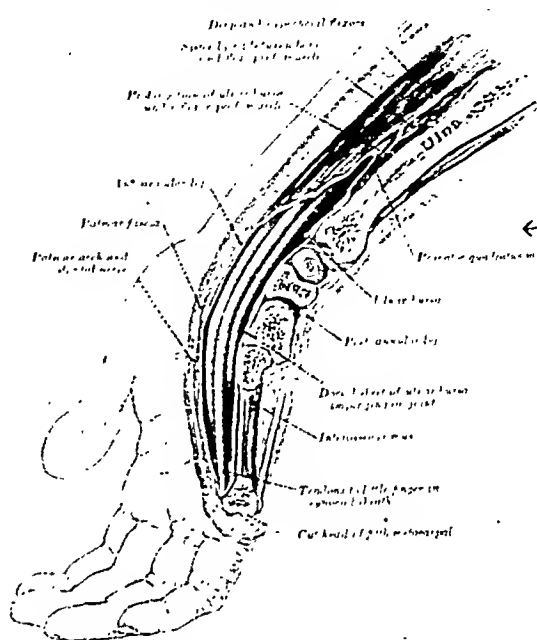
Fig. 3. Sagittal section of wrist showing relation of tendons to bony structures. (After Kanavel.)

tend toward delaying or preventing the return of the injured patient to his regular occupation.

TABLE VII
BONE INJURIES AS COMPLICATIONS

	Cases	Bones
Compound fractures	45	71
Fractures (not compounded)	5	7
Amputations of digits (traumatic)	8	17
Dislocations	4	

58 cases with bone injury and 4 dislocations
95 bones (mostly phalanges) fractured or amputated

In this series of tendon cases thirty-one patients had thirty-nine severed nerves, forty-five patients suffered compound fractures of seventy-one bones, five other patients had seven additional bones fractured without compounding, seventeen bones were partly or totally amputated and four cases had dislocations. Thus beside the extensive tendon trauma inflicted upon these patients we find thirty-nine severed nerves,

four dislocations and ninety-five bones either fractured or amputated in whole or in part. The forces which caused such extensive damage likewise inflicted tremendous destruction to the other soft tissues.

THE TIME OF REPAIR

Every effort should be made to see and repair these injuries at the earliest possible moment, for a primary repair is of great economic value to the patient, and the ultimate functional result following a primary repair is far better than after a long delayed secondary repair has permitted the occurrence of atrophy and scar tissue formation.

It is now an accepted practice not to operate for primary repair of tendon injury unless the patient can be brought to the operating room within a certain limited number of hours as measured from the time the trauma was inflicted. Injuries to the palm of the hand and palmar surface of the digits, all of which are supplied with tendon sheaths, must be repaired before two to three hours have elapsed. Injuries to the volar surface of the wrist must not be sutured any later than three hours after injury. Deep lacerations of the dorsum of the wrist must be operated upon within four hours, while a somewhat longer period of time, within six hours, may be allowed to elapse before repairing severed tendons on the dorsum of the hand and fingers where there are no true tendon sheaths. However, the policy of some is even more conservative; some surgeons never do a primary repair of the flexor tendons of the palm of the hand because of fear of infection but wait and do only secondary repairs. To this extreme policy I do not subscribe because of the protraction of the disability, which, in my opinion, is unwarranted if the necessary precautions are taken to prevent infection when performing a primary repair.

When tendons have not been repaired early a "secondary repair" can be performed after a month's time, provided the wound has healed cleanly and was not too extensive. If no danger exists, an attempt should be made to repair before muscle atrophy ensues. If a spreading infection, especially if caused by streptococci, has contaminated the wound, no attempt should be made at a "secondary repair" for at least six to eight months if one is to avoid the danger of lighting up the old infection. The danger of virulent bacteria lying dormant in the soft tissues is as great in this type of case as it is in open bone reduction after an infected compound fracture, when no surgeon should attempt an open reduction of the fracture for at least six months after the compounding wound is entirely healed. Furthermore, after a severe wound infection there persists for several months a relative degree of edema and tissue infiltration which impairs the structure of the tendon and makes proper suturing difficult or impossible because of the loss of tone of the injured tendon's muscle fibers, thereby making proper apposition of the severed ends unfeasible because of the tension.

TABLE VIII
OPERATIONS FOR TENORRHAPHY

Total cases.........................	344 (347 limbs)
Cases not repaired...............	36 (10 per cent)
Cases repaired....................	311 (90 per cent)
Total tendons....................	870
Tendons not repaired............	70 (8 per cent)
Tendons repaired................	800 (92 per cent)
Primary repair in................	285
Secondary repair in..............	26
Flexor tendons sutured...........	506
Extensor tendons sutured.........	294
Flexor tendons not repaired.......	43
Extensor tendons not repaired.....	27

506 of the 549 severed flexor tendons were repaired
292 of the 321 severed extensor tendons were repaired
No deaths in the 347 cases (311 operations)
Black silk sutures used in 114 cases (294 tendons)
Chromic catgut sutures used in 196 cases (504 tendons)
Linen sutures used in 1 case (2 tendons)

OPERATIONS

In thirty-six cases (10 per cent) operation was not performed for various reasons, such as severely contaminated wounds or refusal by the patient. Twenty-six patients had secondary repairs while 285 had primary repairs, thus leaving a net total of 800 tendons which were repaired at 311

operations. The number of tendons repaired at any one operation varied between one and fourteen, depending on the site and severity of the laceration. The more extensive injuries often required from two to three hours or longer to accomplish a meticulous repair of the damage which was done in a fleeting second. For any surgeon to state that all tendon injuries can be repaired in an hour's time is erroneous.

Black silk sutures were used to repair 294 tendons in 114 cases; chromic catgut 504 tendons in 196 cases, and thin linen sutures in two tendons of one case. No deaths occurred in any of the 347 cases, 311 of whom were operated upon.

The healing of tendons occurs by means of the bridging of the gap by fibrous connective tissue and its successful vascularization. Patients who are more youthful heal their injuries more kindly than do the aged. The flexor tendons which are ensheathed in synovia-like tissue have a less favorable chance to throw out firm fibrous tissue for healing and this fact may be a contributing factor to their less favorable results which are also greatly impeded by restraining adhesions.

INCIDENCE OF INFECTION

Infection is the greatest danger associated with tendon injury if the surgeon does not believe he can thoroughly disinfect the wound and prevent the dissemination of the bacteria into the fertile soil of the surrounding soft parts while exploring the tissues for the retracted ends of the tendons, and unless he has seen the case sufficiently early, he should not attempt to perform a primary repair. These cases should never be drained, for if drainage is necessary the attempt at repair should not be made. The insertion of drains will jeopardize the functional result and will mitigate against that which is most desired, namely, the healing of the wound by primary intention. If the danger of infection is great then the wound should be allowed to heal, and no attempt at a secondary repair should be made for at least one to

six months, depending on the nature and the extent of the infection.

Tendon surgery has been too lightly regarded by many surgeons in the past. The custom of discharging a patient from the ward within a few days after operation is unfortunate, for on several occasions one finds that although the wound was apparently clean on discharge from the ward, the patient subsequently returns to the clinic with an infected wound. The devastating effect of infections in wounds of sutured tendons is the death of the tendon due to the impaired blood supply and its subsequent sloughing out, leaving that part of the limb which it had mobilized completely incapacitated. Extensive infections about the wrist and palm of the hand may destroy all the tendons and cause the patient to be afflicted for the remainder of his life with a claw or useless hand.

TABLE IX
INCIDENCE OF INFECTION—WITH REFERENCE TO "SUTURE MATERIAL" USED

	Infections	Tendons	Percentage
311 repair operations	47	800	15.1
196 cases repaired with chromic catgut	43	504	22
114 cases repaired with black silk	4	294	3.5
1 case repaired with linen	0	2	0
	Infections		Percentage
130 "undrained" cases repaired with chromic catgut	23		17.7
101 "undrained" cases repaired with black silk	3		2.98
	Tendons		Percentage
23 of 311 cases had sterile discharge ("foreign body reaction")	800		7.66
18 of 196 cases repaired with chromic catgut had sterile discharge	...		9.2
5 of 114 cases repaired with black silk had sterile discharge	...		4.3

53 of the 311 cases were drained with the following results:

    21 infections.............. 40 per cent
    7 discharging............. 13 per cent

Analysis of the incidence of infection in the 352 repaired wounds in the 311 patients who were operated upon reveals many enlightening findings, with regard to the type of suture material used, whether the wound was drained, and the location of the lacerated wound. Forty-seven infec-
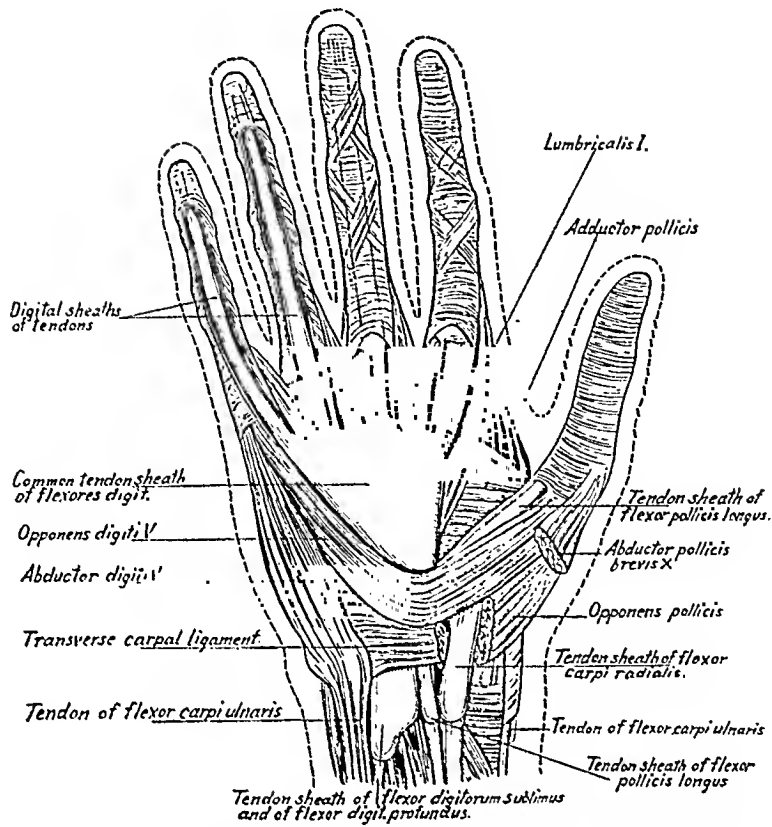
FIG. 4. Flexor tendon sheaths of the palm. (From Moorhead's Traumatotherapy, Saunders.)
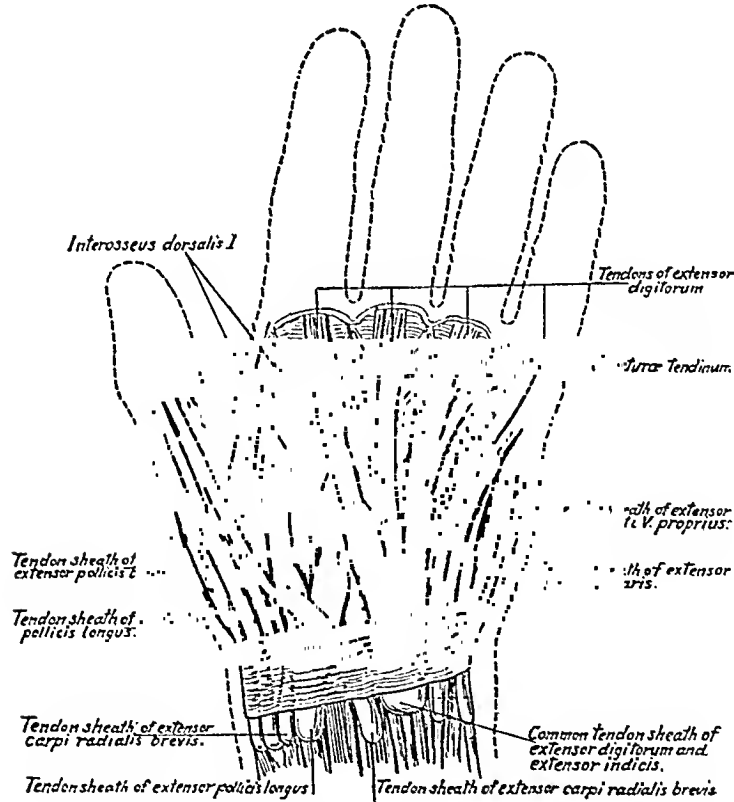
FIG. 5. Extensor tendon sheaths of the palm. (From Moorhead's "Traumatotherapy," Saunders.)

tions occurred in the 311 operations, giving a rate of 15.1 per cent infections for all repaired cases. However, in 101 cases re-

and black silk cases less than half this— 4.3 per cent.

These figures should be conclusive evi-
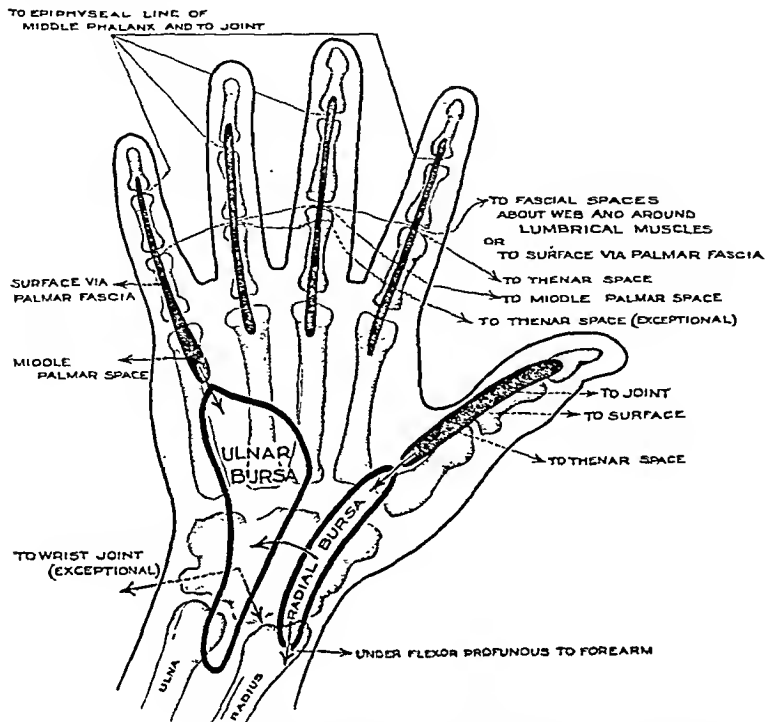
FIG. 6. Modes of spread of infection in hand. (From Moorhead's "Traumatotherapy," Saunders.)

paired with black silk and which were not drained the rate of infection was less than 3 per cent, while in 130 similar cases repaired with chromic catgut the rate of infection was surprisingly high, nearly 18 per cent. In fifty-three cases which were drained, 40 per cent became infected and an additional 7 per cent had discharging wounds, which, when cultured, were found to be sterile. This high percentage of infected cases which were "drained" is in poor light when compared to the rate of infections in "undrained" which was only 11.2 per cent. Combining the drained and the undrained cases, the total infections for cases repaired with chromic catgut was 22 per cent and with black silk 3.5 per cent.

In addition to the infections recorded many wounds had a sterile discharge, probably the result of foreign body reactions, and here again cases repaired with catgut had a relatively higher incidence, chromic catgut reactions being 9.2 per cent

dence in convincing every surgeon against drainage of these wounds and for the use of black silk as the suture material of choice.

Black silk sutures occasionally cause a foreign body reaction if they are in contact with the overlying skin, forming a draining sinus which will usually continue until the suture is sloughed out. However, immediately upon expressing the offending foreign body the wound heals. It is significant that the suture usually holds the repaired tendon ends together long enough to permit healing, and in no such case did the function of the repaired tendon fail to return satisfactorily. Almost all postoperative dressing notes in cases repaired with chromic catgut reported infections, serous discharge or induration of the wounds. In recent years almost all of the injuries were repaired with silk while in the earlier years it was but seldom used in preference to catgut.

Further study of these infections directed toward the "sites" of the 352 lacerated wounds reveals that 25 per cent of the wounds on the flexor surface of the forearm and 20 per cent of the wounds on the volar surface of the wrist as well as 20 per cent on the dorsal surface of the wrist became infected. The surfaces of the hand were proportionately less frequently infected, the palm in 15 per cent, and the dorsum in 11 per cent of the cases. With the exception of the dorsal surfaces of the three lesser fingers which were never infected, the rate of infection varied little for any of the other surfaces of the fingers, all showing between 8 and 13 per cent of infections. In all, 13.3 per cent of the 352 lacerations became infected, 15 per cent being on the flexor surfaces and 11 per cent on the extensor surfaces of the fingers, hand and forearm.

TABLE X

INCIDENCE OF INFECTION—WITH REFERENCE TO "SITE OF LACERATION"

(352 Repaired Wounds of 391 Lacerations Causing Tendon Injury)

Repaired lacerations of	Percentage
"Flexor" surface of forearm	25.0
"Flexor" surface of wrist	20.3
"Flexor" surface of hand	15.0
"Flexor" surface of Digit I	5.9
"Flexor" surface of Digit II	13.0
"Flexor" surface of Digit III	13.7
"Flexor" surface of Digit IV	11.0
"Flexor" surface of Digit V	5.6
"Extensor" surface of forearm	16.7
"Extensor" surface of wrist	20.0
"Extensor" surface of hand	11.4
"Extensor" surface of Digit I	8.0
"Extensor" surface of Digit II	10.0
"Extensor" surface of Digit III	0
"Extensor" surface of Digit IV	0
"Extensor" surface of Digit V	0

14.9 per cent infections in repaired lacerations in wounds on flexor surface

11.1 per cent infections in repaired lacerations in wounds on extensor surface

13.3 per cent infections in repaired lacerations (both surfaces)

The vast majority of the known poor end results were in cases which were either caused by crushing injuries or in wounds that became infected.

SURGICAL REPAIR

The repair of severed tendons and nerves must be attended by excellent surgical judgment, perfect surgical technique, painstaking care and a thorough knowledge of the kinetics of the hand. There is no need to elaborate at length on the surgical procedure but the stressing of several important points is opportune.

1. On admission the wound should be treated with an antiseptic and a sterile dressing applied. A temporary splint should then be fitted so as to hold the hand in a corrected position, with the injured tendons relaxed.

2. Scrub the adjacent skin with soap and water. This is usually best done after the patient is anesthetized. Take care not to wash any further contamination into the wound. The washing of the skin should be done by the surgeon himself. If danger of additional contamination of the wound exists, it is more expedient to omit any scrubbing of the skin than to chance additional infection. Asepsis is all important.

3. Paint the skin with iodine, metaphen, merthiolate, or any other suitable disinfectant. Swab the open wound with the same solution or bathe it frequently with hydrogen peroxide. No wounds so treated in this series of cases became infected and their functional results were not impaired.

4. A débridement of the skin edges and all hopelessly damaged tissue should be done.

5. Do not crush skin edges as primary healing is desired.

6. A tourniquet (or blood pressure cuff) may or may not be used. It is my opinion the use of a tourniquet in severe injuries of this nature predisposes to the death of much of the already traumatized tissue, whose blood supply has been impaired by the original trauma. The danger of a secondary ooze or hematoma also exists. However, some surgeons advocate the bloodless field, and its aid to the ease and
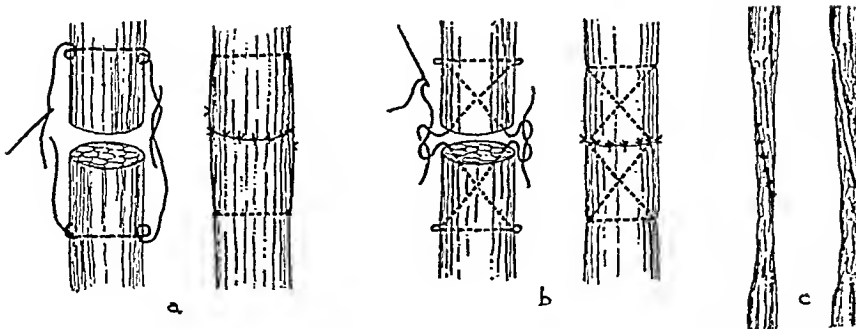
FIG. 7. Method of approximating ends of divided tendons. A, preferred method. B, alternative method. C, method of approximating the fragmented ends of scarred tendons when end-to-end union of freshened tendon ends is impossible because of extensive destruction of tissue. (From Koch and Mason, in *Surg., Gynec. & Obst.*, 1933 and O'Shea, in *Ann. Surg.*, 1937.)
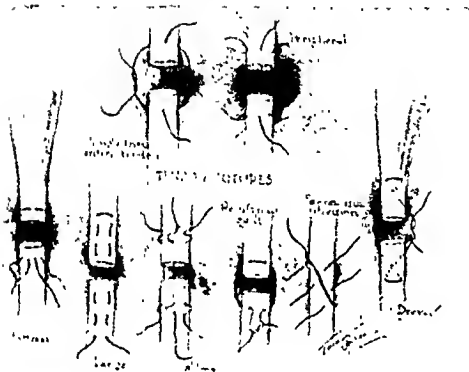
FIG. 8. Further illustration of sutures. (From De Witt Lukens Co.)
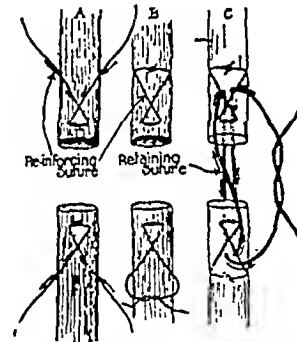
FIG. 9. A new method for tendon and fascia repair, developed by Gratz. (From *Surg., Gynec. & Obst.*, 65: 700, 1937.)
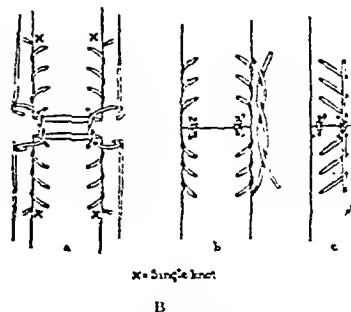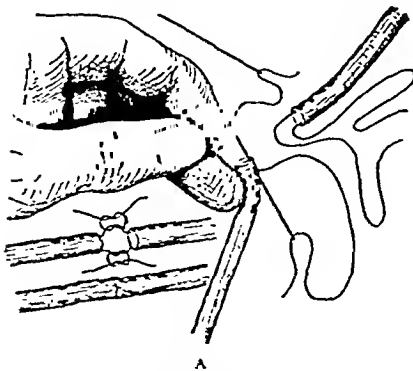
FIG. 10. A, Bunnell's method of approximating the ends of divided tendons. B, Harmer's method. (From Bunnell, in *J. Bone & Joint Surg.*, and Harmer, in *Boston M & S. J.*)

the speed of the operation cannot be denied, as it tends to prevent unnecessary wiping and irritation of these very delicate structures.

joint and the middle phalanx, which have been one of the most frequent injuries noted on our service, it is best not to attempt to repair both tendons. (Fig. 11.)
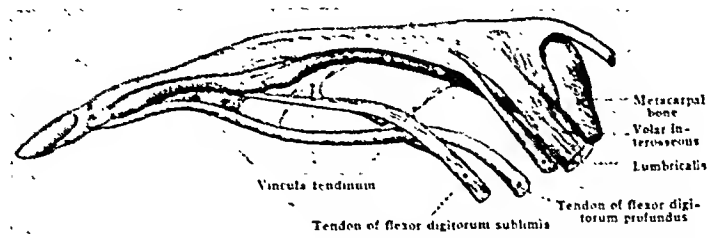
FIG. 11. Interlacing and insertion of tendons of fingers. (From Toldt's "Atlas of Human Anatomy" and Morris' "Anatomy.")

7. Handle all structures, especially the nerve ends, with the greatest of gentleness. Do not crush the tendon ends with clamps and do not use any sharp instrument in handling a nerve.

8. Avoid, if possible, cutting across the normal flexion creases of the skin of the digits. Make a lateral rather than a midline incision. Avoid splitting tendon sheaths and vaginal ligaments in searching for the proximal end. Make an incision at a more proximal level, if necessary.

9. The use of fine black silk sutures is advocated for tendon repair as compared to the use of chromic gut, which often tends to tear the tendon when being passed through its substance, and which also causes more absorption reaction in tissues which frequently have no true circulation but are only bathed in lymph. The danger of infection is appreciably less when silk is used in place of chromic catgut. The finest grade of silk that will give the required tensile strength should be used.

10. In my opinion, a single through and through suture or a wide mattress suture about 0.5 to 1 cm. away from the severed ends will approximate the main bodies of the tendon fragments. A few interrupted single sutures at the free edges will improve the position of the opposing fiber ends. (Figs. 7A and 8.) More fanciful stitches as illustrated below are usually unnecessary. Simple approximation is best.

11. In lacerations of both digital flexor tendons between the metacarpophalangeal

At this point the superficial flexor tendon splits to permit the long flexor to pass through it. Repair only the long flexor— the profundus. If one repairs both at the same level, a large scar tissue growth will develop, causing adhesions between the tendons themselves and the surrounding soft parts. One slip of the splitting insertion of the flexor sublimis tendon may then be used to form a new annular phalangeal ligament by passing it over the profundus tendon and sewing it to the lateral expansion of the digital extensor tendon. The formation of this new annular ligament will give a much better functional and cosmetic result.

12. When a tendon has been hopelessly destroyed and function inevitably doomed, it is often expedient to substitute other tendons in its place. The following substitutions are usually the best (Fig. 12): the palmaris longus sutured to the distal end of the abductor pollicis longus; the flexor carpi ulnaris to the extensor carpi radialis and the flexor carpi radialis to the extensor digitorum communis or the extensor pollicis longus are other attachments of choice. Tendons which have healed with marked shortening may be lengthened at a later date by any of the illustrated methods in Figure 13. These attempts are not always met with such good results, mostly because of the small width of the tendons in the area of the wrist.

13. Great effort should be made to cover the repaired tendon or nerve with sub-

cutaneous tissue or fascia before suturing the skin. This usually prevents undesirable adhesions. The skin edges should be care-
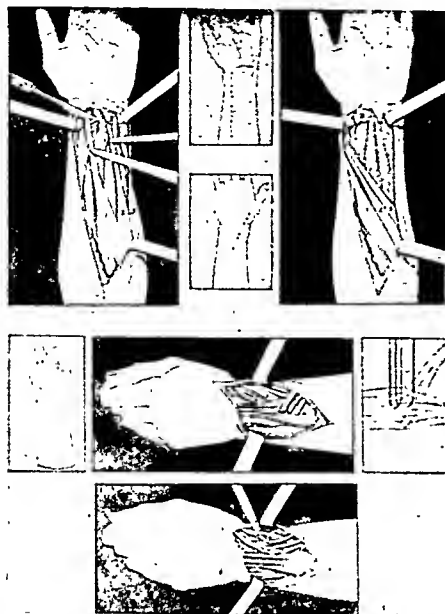
FIG. 12. Tendon transplants for loss of tendon or nerve paralysis. (From M o o r h e a d ' s "Traumatotherapy," Saunders.)

fully sutured to insure primary healing. If there is a "full thickness" loss of skin over an area that cannot be sutured to heal by primary intention, then a full thickness pedicle skin graft should be done as soon as possible.

14. The loss of substance of a tendon may sometimes be overcome by passing black silk sutures through a tunnel formed by a vein taken from another part or limb and then passing the suture through each severed end of the tendon. Within a space of a few weeks fibroblasts will have formed a new pseudotendon.

15. Do not drain these wounds. If drainage is necessary, surgery should not be attempted. Drained wounds are more apt to become infected.

16. A moulded plaster splint should be applied to immobilize the fingers and hand in either acute flexion or acute extension to relieve tension on the repaired parts. This splint should be modified and replaced from time to time during the postoperative course, as the angle of immobilization is

made less acute. The injured limb should be elevated or suspended overhead for six days following operation, as these wounds
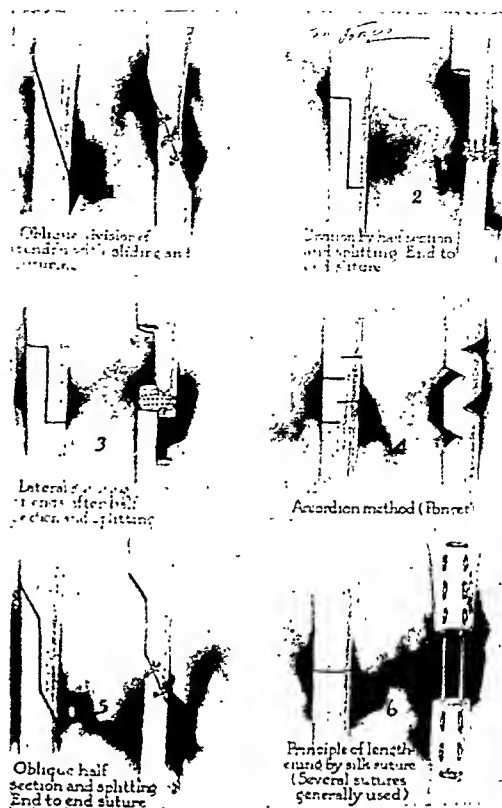
FIG. 13. Methods of tendon lengthening. (From DeWitt Lukens Co.)

by their very nature are potentially infected. The elevation also will tend to prevent any venous oozing from small unligated venules, and will make the patient more comfortable by relieving him of that distressing and not infrequent postoperative complaint, "throbbing."

17. "Bed rest" of the injured arm and the whole body should be insisted upon for at least one week.

POSTOPERATIVE TREATMENT

The after-care of these patients is just as important as is the operation, if they are eventually to obtain a good functional result. I believe these patients would obtain the best results if they were given bed rest for a week or ten days and hospitalized for three to four weeks postoperatively and not referred to the clinic. Although the expense would be great, the ultimate eco-

nomic result to the patient would compensate for the added cost. An infection or extensive adhesions with resultant "poor" functional result may cause a patient far greater discomfort, disability and loss of earning power than any fracture, hernia or any other form of traumatic injury.

The surgeon should see the patient every day for the first three weeks and commence gentle movement of the fingers two to seven days following tendon repairs, gradually increasing the range, taking care not to cause parting of the sutured skin wound. When silk is used in place of catgut sutures the tensile strength is better and motion can be started at an earlier date. The reaction of "pain" is a guide to the range of motion to be attempted at different stages. Following operation there should be adequate physicotherapy and well guided exercises and hobby or occupational therapy for several weeks. Typewriting and piano playing are great assets in reëstablishing function, as the patient's mind becomes partly distracted from his physical inadequacies and he will persist for longer periods of time in these gainful exercises. The system of exercises should be based on an anatomic interpretation of the joint movements involved. Exercises and physiotherapy will tend to reduce the obstructive edema which is one of the main factors in retarding reestablishing normal movements. The physiotherapist is an important cog in the rehabilitation of these injured hands and forearms.

FUNCTIONAL RESULTS FOLLOWING TENORRHAPHIES

Although this series of cases extends over fifteen years, "follow-up clinics" have only been maintained for the last six and a half years of this period. Consequently the final results of many cases could not be ascertained. The following figures are therefore based mostly on the cases of the last seven years or less. Since the optimum result in these cases usually cannot be expected for at least six months, and since many of the cases are of recent

date, the data of their end results must necessarily be prejudicial. Severed extensor tendons of the dorsum of the hand and digits gave the most satisfactory results (95 per cent), while injury to the extensor tendons of the wrist was followed by 88 per cent good results. Of the fifty-two cases of severed extensor tendons which were followed-up, 94 per cent ended satisfactorily.

TABLE XI
FUNCTIONAL RESULTS FOLLOWING TENORRHAPHIES
(Based on a Follow-up of 123 of the 311 Operative Cases
The End Results of 40 Per Cent of the Operative Cases

Tendons Involved	Excellent Results	Good Results	Unsatisfactory Results	Total of Each Type	Percentage of Satisfactory Results
Flexors of wrist.........	10	11	5	26	81
Flexors of fingers........	9	20	16	45	65
Total flexors..........	19	31	21	71	70
Extensors of wrist.......	5	2	1	8	88
Extensors of fingers.... ..	23	19	2	44	95
Total extensors........	28	21	3	52	94
Total cases...........	47	52	24	123	80.5

The severed flexor tendons were not favored with such good results from anatomic, functional and economic viewpoints. This is due to a great extent to the fact that these tendons are usually encased in tendon sheaths and have flimsy vinculae which are easily severely injured by trauma. A laceration on the palmar surface usually severs two tendons while a similar laceration on the dorsal surface of the hand and fingers, with the possible exception of the thumb and index finger, usually severs only one tendon. Only 65 per cent of the laterations of the flexor tendons to the fingers ended satisfactorily, and 81 per cent of the flexors of the wrist terminated favorably, to give a total for seventy-one cases of severed flexor tendons of 70 per cent satisfactory end results. Of the 123 known results for all types of tendon injury, 80.5 per cent had good results.

Analysis of the twenty-four known unsatisfactory results reveals that 87.5 per

cent of these were in flexor tendons of the hand or wrist and only 12.5 per cent on the extensor surfaces. There were three unsatis-

FIG. 14. Relation of nerves to tendons in forearm. (After Sobotta.)

factory end results in extensor tendon cases. Of these, one was a case of marked loss of substance of the extensor tendon, one followed infection, and the third was a crushing injury of the wrist with fracture of the radius and considerable soft tissue destruction. Of five poor results on the volar surface of the wrist, two were following crushing injuries and two had infected wounds while the other was due to improper immobilization and insufficient after-care. The vast majority (67 per cent) of the unfavorable results were in flexor tendons of the palm of the hand or the proximal row of phalanges where the tendons are interlaced. Most of these patients had both the flexor digitorum profundus as well as the flexor digitorum sublimis tendon severed; in my opinion,

an error was made in repairing both tendons, with resultant adhesions and loss of function. In three cases infection took
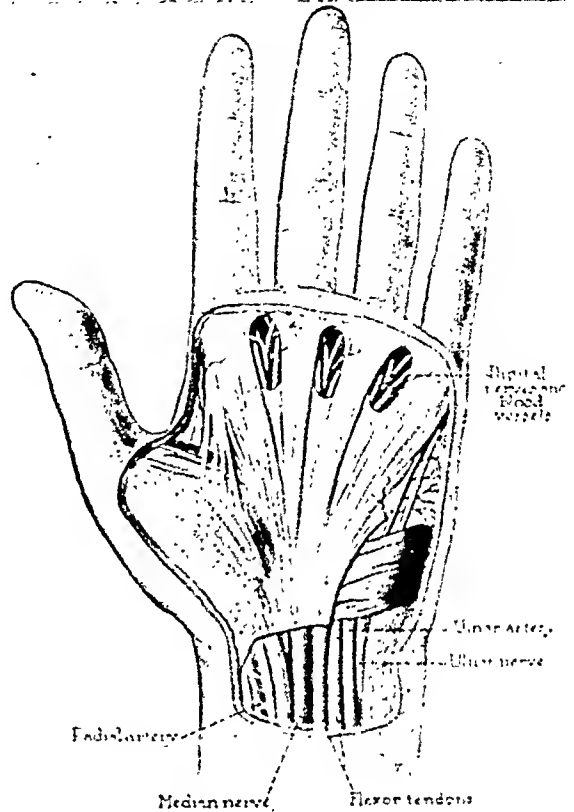
FIG. 15. Dissection of the volar surface of the wrist showing the superficial position of the median and ulnar nerves, and the similarity in size between the median nerve and the superficial flexor tendons. (After Sobotta. From Koch and Mason, in *Surg., Gynec. & Obst.*, and O'Shea, in *Ann. Surg.*)

place and in one of these cases the flexor tendons sloughed out. Many of these unfavorable results could have been prevented if the repair had been made with black silk sutures and motion started at an earlier date. Some of the cases were immobilized in splints for too long a period of time, and a few of the patients were most uncoöperative in efforts that were made in their behalf to rehabilitate them. A severe "crushing injury" with fracture of one or more bones was not infrequently followed by a poor result.

INCIDENCE OF NERVE INJURIES

The fifty-seven nerves which were severed were in forty-nine patients, thirty-one of whom had additional tendon injuries and eighteen of whom were admitted for

TABLE XII

ANALYSIS OF 57 SEVERED NERVES

57 Nerves were severed in 49 Cases
31 Cases had Tendon Injuries—18 Cases uncomplicated
6 Nerves were not repaired (infected wounds or partially severed)
8 Patients had 2 nerves severed
30 Lacerations in right limb and 27 in left limb
54 Nerves severed in 47 males, and 3 nerves in 2 females
52 Nerves severed at wrist, 4 in forearm and 1 in hand
29 of 32 ulnar nerve lacerations were at wrist
19 of 21 median nerve lacerations were at wrist

Right (30)
{
14 Ulnar Nerves
12 Median Nerves
3 Radial (branch)
1 Musculo-cutaneous
}

Left (27)
{
18 Ulnar Nerves
9 Median Nerves
}

Complications: Neuromata, trophic ulcers and adhesions to scars of tendons.

nerve injuries alone. Six of these nerves were not repaired, either because of gross contamination of the wounds or because they were only partially severed. The surgeon, whether erroneously or not, believed they should not be repaired. Only two of the forty-nine patients were females and they suffered lacerations of three nerves. The remaining fifty-four severed nerves were fairly evenly divided between the two sides of the body, thirty being in the right side and twenty-seven in the left side of the males. Eight of the patients had two nerves severed.

The volar surface of the wrist was the site of injury of the vast majority of these cases—fifty-two being at the wrist, four in the forearm and one in the hand. Many additional digital branches of the main nerves to the hand were severed, but because of their relative lack of importance they have not been included in this series. Likewise no injuries in the upper arm, such as are sustained by lacerations, or by fractures of the humerus causing injury to the radial nerve are included. Twenty-nine of the thirty-two ulnar nerve lacerations were at the wrist, and nineteen of the twenty-one median nerve injuries occurred in the same location.

OPERATIONS

Operations were performed on fifty-one of the fifty-seven severed nerves. All but fifteen of these operations were for primary repairs, and these fifteen were sutured at secondary repair operations at time intervals that varied between two months and two years after the initial injury was sustained.

Severed nerves may be complicated by formation of "neuromata" between their repaired ends if there is a poor approximation of the nerve tissues. A rotation of part of the nerve trunk may also mitigate against a favorable outcome. "Trophic ulcers" are not infrequent complications, and are more commonly found after ulnar nerve injury than following severance of the median nerve. The predisposition for such an ulcer can be accentuated by the excessive pressure of a splint improperly applied. Great danger of a burn or ulcer exists if diathermy is used erroneously.

Adhesions of the tendon scars to the damaged nerve may cause the patient considerable distress. The regeneration of sensory power after ulnar nerve lacerations and repair is more rapid than is the motor function, which frequently may not occur until at least one year later.

Infections are not as dreaded a complication here as they are in tendon injuries and none of the eleven cases which were operated upon for nerve injury alone became infected.

TECHNIQUE OF NERVE SUTURING

All severed nerves should be sutured with about six to eight interrupted black silk sutures passed through the neurolemma sheath. (Fig. 19.) In addition, the passing of a suture through the trunk of the nerve about 1 cm. from its severed ends, before freeing it from its surrounding soft tissue bed, apparently does not seriously injure any nerve fibers, as it passes through the substance of the nerve. It has the advantage of preventing a rotation of the nerve ends after they have been freed from the surrounding structures and gives better apposition of the injured parts. (Fig. 20.) The constant irrigation of the wound with saline while suturing the nerve diminishes

the probability of the formation in its trunk of scar tissue due to the absence of any blood between the opposing severed ends.

A partially severed nerve should be repaired to prevent scar tissue formation hindering the regeneration of the nerve
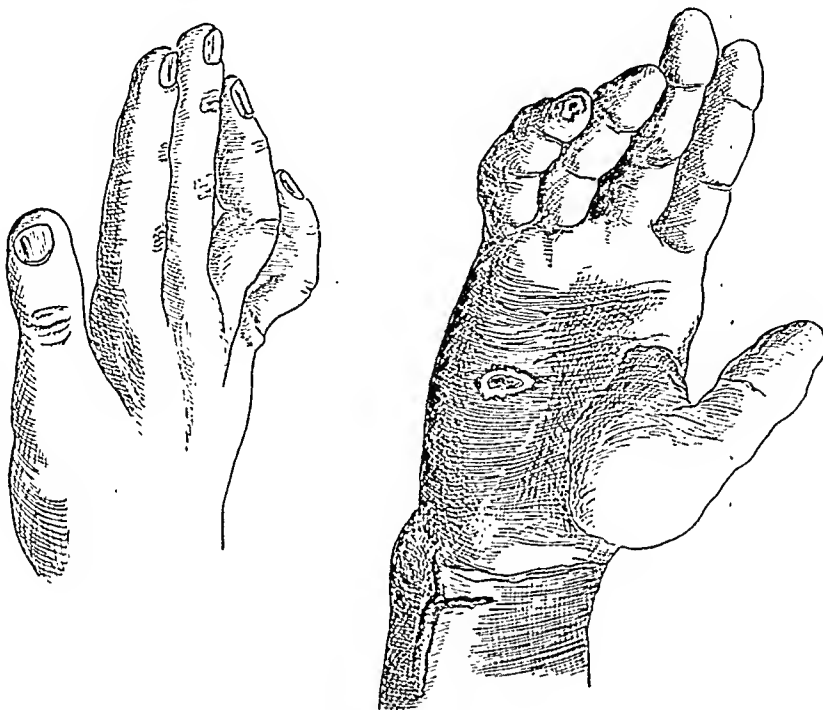
FIG. 16. Trophic ulcer following severance of ulnar nerve. (From O'Shea, in *Ann. Surg.*, 1937.)

Some surgeons advocate the encasing of the repaired nerve in a pad of fat from the abdominal wall or a piece of a vein from

FIG. 17. Distribution of cutaneous nerves of the anterior and posterior aspects of the superior extremity. (From Morris' "Anatomy," Blakiston.)

the neighboring parts, so as to prevent adhesions, but this is usually unnecessary. (Fig. 21.)

fibers in their axis cylinders. Handle all nerves with the greatest of care and gentleness. If the nerve was severed in such a manner as to leave jagged ends, cut them cleanly across with a sharp scalpel and approximate the ends perfectly. Here, as in repaired tendons, a moulded plaster splint must be applied to hold the wrist in a position where all tension is removed from the repaired nerve for three weeks' time (which is a longer time than for tendon immobilization). If tension is too great on a severed ulnar nerve injured in the forearm, it is best to transplant it to the anterior surface of the elbow joint.

FUNCTIONAL RESULTS FOLLOWING NERVE SUTURING

Of the fifty-one repaired nerves of the forearm the end results of only 41 per cent are recorded. This is partly due to the fact, as already explained, that in the first half of this period of years no follow-up clinic was maintained, and partly because cases

repaired in the past year have not had ample time to manifest their optimum results.

frequently fails to return even after suture of the severed nerve has been followed by regeneration of the sensory fibers.
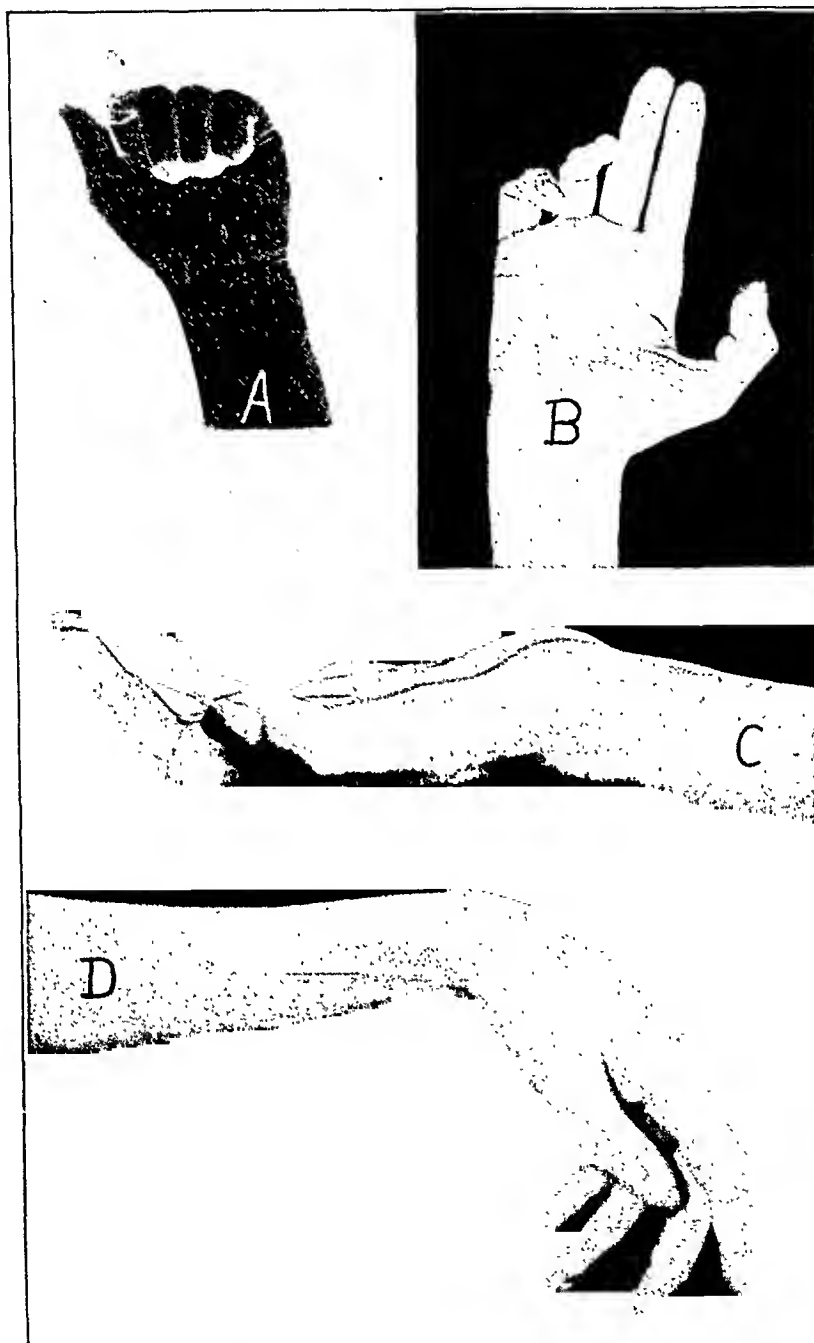
FIG. 18. Deformities which indicate the nerve severed. A, median. B, ulnar, C, median and ulnar. D, radial (drop wrist). (From Morris' "Anatomy," and O'Shea, in *Ann. Surg.*, 1937).

When the ulnar nerve is severed above the wrist and the nerve is not repaired the patient may develop a claw hand with poor function of his thumb and loss of the fine movements of the fingers, due to paralysis of both the dorsal and volar interosseus muscles and two of the lumbricals. The functional loss of these small muscles

When the median nerve is severed above the wrist and the nerve is either not repaired or improperly repaired, an "ape hand" may result. The patient will have anesthesia on the palmar surface of the thumb, index and middle fingers, and the thumb will be adducted due to paralysis of the abductor pollicis brevis muscle.

In the cases in this series which were followed up the results were fairly satisfactory. Seven of the ten severed ulnar nerves

regeneration of its sensory fibers, which are its only fibers after leaving the arm.

Of the total fifty-seven severed nerves
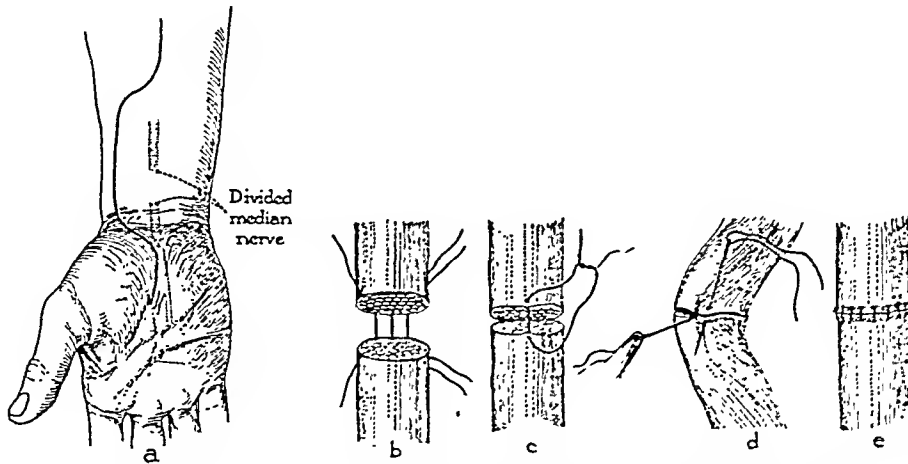
FIG. 19. Technique of nerve suture. A, incision of choice for exposing divided median nerve just above wrist. If necessary, incision may be continued proximalward and distalward in vertical direction. B, suture is inserted at exact midpoint of dorsal surface of nerve. Other supporting sutures are inserted close to it before first is tied, to prevent first suture tearing through delicate epineurium as nerve ends are drawn together. (From Koch and Mason, in *Surg., Gynec. & Obst.*, and O'Shea, in *Ann. Surg.*)

showed complete regeneration of the sensory fibers and partial return of the fine movements of the fingers, such as abduction and adduction from the median axis. However, only two manifested complete motor return. This latter finding is in accord with most investigations. The total satisfactory results of ulnar nerve injuries were 70 per cent. Of the median nerve,

FIG. 20. Through and through suture of the nerve trunk.

78 per cent showed satisfactory results, and in the two superficial radial nerves which were severed and followed-up both manifested a complete return of function. The one recorded severance of the musculocutaneous nerve, and I believe there must have been many more from the location of the lacerations, was followed by complete

the end results of twenty-two are known. Of these twenty-two known results, seventeen or 77 per cent were satisfactory.

TABLE XIII

FUNCTIONAL RESULTS FOLLOWING NERVE REPAIRS

Follow-up Results

	Percentage
18 of the 49 patients.....................	37
22 of the 57 severed nerves...............	40
21 of the 51 repaired nerves.............	41
10 of the 32 ulnar nerves.................	32
9 of the 21 median nerves...............	43
2 of the 3 radial (br.) nerves.............	67
1 of the 1 musculocutaneous nerves......	100

End Results

	Satisfactory	Percentage
22 known results................	17	77
10 ulnar nerve results...........	7	70
9 median nerve results..........	7	78
2 radial nerve results...........	2	100
1 musculocutaneous nerve results	1	100

CONCLUSIONS

Tendons. 1. Primary repairs of tendons should be performed whenever possible. The time between the injury and the operation should be as short as possible and the suture material of choice is fine black silk.

2. The simple mattress stitch will approximate the tendon ends and destroy fewer lymph channels. More elaborate methods of suture are unnecessary and may be harmful as they tend to diminish the circulation in the tendon and prolong the operation.

3. Do not repair both digital flexor tendons in the hand. Repair only the long flexor—the profundus.

4. Repaired wounds should never be drained. If drainage is necessary, do not perform a primary repair. Drained wounds showed 40 per cent infections.

5. Infection occurred almost twice as frequently at the wrist as on any surface of any digit.

6. Infections occurred in 15 per cent of all operations, but in less than 3 per cent of 101 non-drained cases repaired with black silk sutures, while in 130 non-drained cases repaired with chromic catgut nearly 18 per cent infections resulted.

7. Infections and "foreign body" drainage reactions are alarmingly high if wounds are drained or sutured with chromic catgut.

8. A "full thickness" skin graft should be performed as soon as possible when there is an evulsion of skin from over tendons or nerves.

9. The presence of ninety-five fractures or traumatic amputations and four dislocations in fifty-eight cases considerably complicated the treatments and end results.

10. Start motion at an early date. The use of black silk permits this, because of its increased tensile strength and fewer edematous reactions.

11. A patient should be hospitalized for at least two weeks, and in the first week he should be kept in bed to give maximum rest to the hand. Elevate the hand for several days.

12. The "end results" are impaired and retarded by the numerous fractures and severed nerves which necessitated prolonged immobilization in splints.

13. The end result is greatly dependent upon the surgeon's personal management during the first three or four weeks of postoperative care.
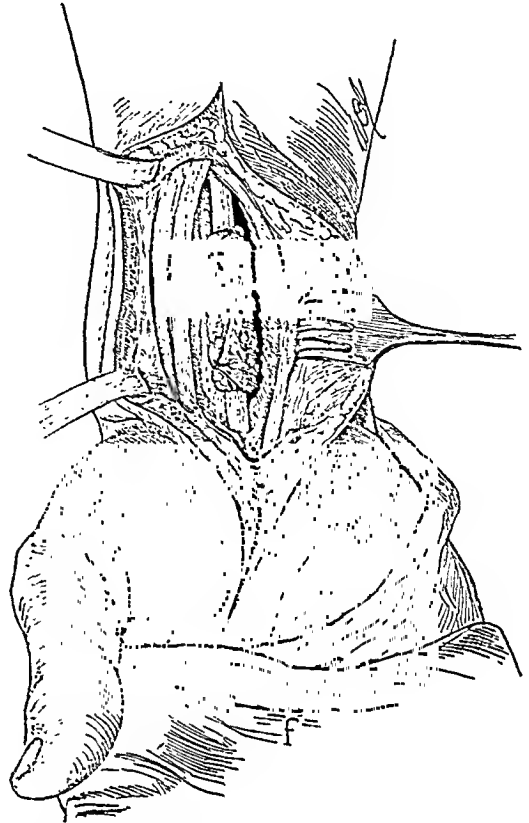
Fig. 21. Skin fat transplant to protect line of suture in nerve. (From Koch and Mason, in *Surg., Gynec. & Obst.*, and O'Shea, in *Ann. Surg.*)

14. A follow-up of 40 per cent of the repaired tendon cases is recorded, showing satisfactory functional results in 80.5 per cent of the cases. All extensor tendons showed 94 per cent satisfactory results, the flexor tendons of the wrist 81 per cent, and the digital flexor tendons, which were severed in the palm of the hand or fingers, only 65 per cent satisfactory results.

Nerves. 1. A partially severed nerve should be repaired in order to prevent the formation of scar tissue, which hinders regeneration of the nerve fibers.

2. A follow-up of 40 per cent of the repaired severed nerves showed satisfactory functional results in 77 per cent of the cases.

3. Seventy per cent of the ulnar, 78 per cent of the median and 100 per cent of the superficial branch of the radial nerve

injuries showed satisfactory evidence of regeneration.

4. Motor function is difficult of restoration in lacerations of the ulnar nerve above the wrist.

5. It is essential to stress the necessity of perfection of the surgical technique and asepsis as well as gentleness in the handling of the tissues in these cases.

6. No deaths occurred in any of the 311 operative cases of tendon or nerve injuries.

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SPONDYLOLISTHESIS: SUGGESTIONS FOR TREATMENT

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FOR many years attention has been focused on the subject of low back pain, and the ever increasing interest is readily appreciated when one considers the disability and consequent loss of earning power which ensues, together with the constant drain on the resources of insurance companies which has resulted from the plea of etiologic trauma. Radiology has helped considerably in the differentiation of the various causes of the pain, but it is only in recent years that more accurate observation and knowledge have resulted in the more frequent diagnosis of spondylolisthesis as a separate entity in the causation of this troublesome symptom.

Killian, in 1852, gave the name *spondylolisthesis* to a deformity produced by a gradual gliding or slipping forward of the vertebral column on the sacrum or on the fifth lumbar vertebra. The deformity may be defined as a forward subluxation of the body of the fourth or fifth lumbar vertebra, together with the superimposed vertebrae, on the vertebra below or on the sacrum. In the cases seen by the author the vertebra most commonly displaced has been the fifth lumbar, and only slightly less frequently the fourth lumbar vertebra. Although a similar condition has been described at other parts of the column he has not had personal experience of this.

The displacement varies from one that is only recognizable, to such an extreme degree of dislocation that the displaced vertebra is actually situated in front of the first or second, or even the third, sacral segment. The displacement is usually accompanied by some degree of rotation on a horizontal axis, so that the normal upper surface may eventually look directly forwards.

The term *spondylolisthesis* is, of course, not used for those dislocations which result from acute trauma, tubercle or other infections, and tumors of bone, but only for a gradual process without evidence of disease.

Incidence. At one time spondylolisthesis was rarely discovered except as a cause of difficult labor and, indeed, the most elaborate treatise written on the subject was that of an obstetrician—Neugebauer of Warsaw—who believed that the deformity was related to the female sex only. It is now evident that it is even more common in males. Until 1900, 125 cases had been reported in the literature and all but six by obstetricians; but in twenty-three years in the Mayo Clinic, 207 cases were reviewed of which 71 per cent were males. As a criterion of the increased frequency of the condition, two cases were seen at the Mayo Clinic in 1918, while in 1931 forty-six were reported.

Patients complaining of the symptoms of spondylolisthesis are usually middle-aged, but many appear to have had backache most of their life. The youngest patient on record was 5 years of age, while the oldest was 80.

Etiology. Such a variety of causes has been put forward to explain this interesting deformity that it would appear that either the true cause is unknown or there may be more than one single factor in its production. A mere tabulation of the causes from the literature would fill several pages, but many of them bear a similarity and they may be classed in three groups: (1) a developmental anomaly; (2) trauma; and (3) arthritis. Increasing experience tends to confirm the opinion that spondylolisthesis is primarily the result of a congenital cleft in the laminae of the neural arch and

this has been a constant finding in every specimen of spondylolisthesis studied. The break in the continuity of the bony neural arch occurs between the superior and inferior articular processes of the lumbar vertebra and releases the body of the vertebra with its superimposed column which together slip forward.

The Primary Congenital Anomaly. A typical vertebra ossifies from three primary centers and five secondary centers. The three primary centers are situated in the body and in each half of the vertebral or neural arch, and the five secondary centers appear at the tip of the spine, the tips of the transverse processes, and the upper and lower surfaces of the body. The primary centers for the arch appear at the roots of the articular processes, and from them the arch and its processes are ossified and also the posterolateral parts of the body—the parts of the body which, in thoracic vertebrae, articulate with the ribs. An important variation in ossification occurs in the fifth lumbar vertebra, which may have two primary centers in each half of the arch, the two parts of each half being united by a plate of cartilage set obliquely between the superior and inferior articular processes. The posterior part of the arch of the fifth, comprising the spine, laminae, and inferior articular processes, is occasionally separated from the rest of the bone owing to non-fusion of the two anomalous centers, union during life being effected by hyaline cartilage. The same condition may be seen in the fourth.

Because of the evolutionary change from the horizontal to the upright position, and the late closure of the neural arches, the lumbosacral joint and the fifth lumbar vertebra are the sites of more anomalies than any other part of the spine. Spina bifida occulta, separate neural arches, and sacralized transverse processes are examples of such congenital abnormalities, but it is those cases in which the whole of the posterior segment, including the inferior articular processes, laminae and spinous process have failed to fuse to the anterior segment which are of interest in this discussion. This abnormality, where the whole of the posterior segment of the vertebra is separate, is most common in the lumbar region but has been described in the first sacral vertebra by Sandifort, and in the cervical and thoracic region by Neugebauer, who has also described it in the third, fourth and fifth lumbar vertebrae of one spine.

Willis found a separate neural arch in seventy-nine out of 1,520 human skeletons that he dissected, i.e., in more than 5 per cent. He found that at the seventh or eighth week a single center of ossification appeared in each half of the neural arch near the base of the superior articular process. This extends forward to the body, with which it does not fuse until the fourth or fifth year, and backwards to the transverse process, lamina and spinous process. He found that in strong transmitted light there appeared to be two separate areas of dense bone in each half arch connected indefinitely by a narrow isthmus just distal to the developing superior articular process. Serial sections showed that these dark areas were centers of ossification made up of young bony trabeculae. From the anterior expansion developed the anterior part of the half arch, from the posterior, the lamina, inferior articular and spinous processes. Willis found that the two centers are connected by a neck so small that it appears in only one-sixth of the serial sections, while the expansions are cut by nine-tenths of them. In those sections which do not cut the isthmus there appear to be two centers for each half arch. Since true ossification follows invasion by blood vessels, it is certainly possible that as the artery divides at this point into ascending and descending branches, either before or after entering the bone, bone development may progress in a similar manner, and, expanding out in both directions, be defective centrally. Embryologically, therefore, this defect falls into the category of anomalous ossification, of which there are many other examples scattered over the

skeleton. It is peculiar to the lumbar region and may be found in any lumbar vertebra, although usually confined to the last.

It would appear, therefore, that a congenital origin is the probable explanation of the separate neural arch, in spite of possible weakness in the embryologic evidence.

However, a separate neural arch does not necessarily mean spondylolisthesis, as Brailsford has shown. He has figured two instances of dissected specimens showing a separate arch without evidence of fracture and without evidence that spondylolisthesis had occurred. But it is in those cases in which the whole of the posterior segment, including the inferior articular process, laminae and spinous process, has failed to fuse with the anterior segment that the possibility of displacement has to be considered.

If this congenital error be the primary factor in the etiology of a spondylolisthesis, what are the secondary factors which initiate the displacement and consequent deformity?

Normally the tendency to forward displacement of the fifth lumbar vertebra, produced by the shearing strain at the lumbosacral angle, is prevented by the anatomic locking or clamping together of the fifth lumbar vertebra and first sacral vertebra through the coaptation of their articular processes. But if any solution of continuity be present, as in the separate posterior segment described, displacement may occur owing to the superincumbent weight acting as a shearing strain. This slipping will affect only the anterior part of the fifth lumbar vertebra, there being no real locking of the interarticular joints. Under normal conditions this narrow part of the last lumbar vertebra—well named by Chandler the *isthmus*—is subjected to extreme forces. Situated at a critical point at the junction of a mobile and immobile part of the spine, in an area obviously designed for the quadrupedal, and which has undergone little modification since the transition to the vertical, position, it

becomes unbelievable to what stress it may be subjected when the normal strain of weight-bearing is increased by motion,

Fig. 1. The ossification of the vertebral arch.

leverage and muscle spasm resulting from sudden strains or falls. The normal isthmus of intact bone may withstand this shearing force, but it is likely that when there are two secondary centers here the strains prove too much and a gradual solution of continuity is produced by the summation of stress and strain of the trauma of normal childhood. Brailsford suggests that the trauma may be at a "very early age" and may even occur at childbirth from a mother with a deformed pelvis. He says that while spondylolisthesis in the mother leads to difficulty in childbirth, difficulty in childbirth may lead to spondylolisthesis in the child.

Whether we accept this theory or not, it is not unlikely that displacement is initiated before the age of 10, for it is about this period that fusion of the two centers in question takes place. Until this time a comparatively weak union exists between these important components of the vertebrae, the strength of which preserves the integrity of the spinal column. If for any reason a severe strain is put on this isthmus, either from nothing more than excessive weight in a rapidly growing

child, or the sudden severe strain of trauma, or even the summation of strains from some particular game or occupation,

FIG. 2. The appearance of spondylolisthesis.

it is not unreasonable to suppose that there may occur here a condition of affairs analogous to what occasionally happens in the hip joints of children at a later age—a slipping or separation of an abnormal epiphysis.

Such a theory, too, would explain those cases where the lumbar body has been described as elongated anteroposteriorly; for a slipped epiphysis does not necessarily mean a complete solution of continuity, but may appear only as a stretching of the actual cartilage, which may later ossify and hold the body in a position which, though displaced forwards, becomes stable since the arc has become united. If the separation is complete, then the stage is set for a complete spondylolisthesis. However, this will probably be a slow process as in the young child the subsidiary factors of anterior spinal ligaments and interspinous ligaments may hold the parts for years. These ligaments slowly lengthen, however, and the body continues to slip. With displaced body and stretched ligaments, pain inevitably supervenes, and a later trauma may cause a further stretching and dis-

placement. It is probable, therefore, that in many cases this trauma is of considerable etiologic importance.

In spite of the fact that the supports of the spondylolisthetic fifth lumbar vertebra are insecure, the displaced body may come to a final position of rest after making only a moderate forward movement. Natural arrest is favored by several factors. One of these is the iliolumbar ligaments, slanting from the transverse process of the vertebra to the iliac crest. The restraining influence of these ligaments is aided by the tendency of the pelvis to assume a more vertical position by rotation on its transverse axis. Bone often proliferates on the anterior surface of the sacrum beneath the displaced portion of the fifth lumbar vertebra, forming a buttress of sufficient strength to prevent further slipping.

The Clinical Picture.   Generally there is a history of single or repeated trauma, but this is by no means constant and often no history of injury can be elicited. The patient's first complaint is of pain in the lumbar region, coming on usually about puberty, but sometimes initiated by parturition. The pain is at its maximum in the lumbar region and radiates down the legs. It is made worse by prolonged standing, especially in the bending position as in washing, by the carrying of heavy objects, and by any exercises which entail mobility in the lumbosacral region. It is relieved by rest. The pain is frequently of a very severe nature and in a recent case even walking had to be curtailed to a minimum and yet, in spite of limitation of physical exertion, the patient's face showed the evidences of her long suffering.

On examination the profile of the patient is the most striking feature. The trunk appears to be shortened, as it must be because the spine is telescoped into the pelvis. Encircling the trunk, just below the rib margin, is a well marked and often deep skin crease. This is seen on both sides behind and sometimes folds of the skin project down over the pubis. The rib margin approaches the iliac crest and the

brachial birth palsy, and it is these secondary changes with which the orthopedist has most frequently to deal.

First to appear among the secondary pathologic changes is muscle paralysis dependent directly on the nerve injury. The muscles affected are of course those supplied by the injured nerve. The paralysis is flaccid, being of the peripheral type and is accompanied by atrophy of the paralyzed muscles. It affects various groups depending on the injured nerves. This paralysis of groups of muscles leads to unbalanced muscle action with contractures and deformities resulting. These contractures in turn lead to distortions and deformities in the joints, particularly the shoulder, where subluxation is common, and in the elbow, where a displacement of the radial head is often seen.

Among the secondary pathologic changes are changes in the bones of the affected arm which are shorter and frequently smaller. These changes are usually ascribed to lack of use, but we are tempted to believe that they are a direct trophic effect of the nerve injury. We have noted quite regularly that the appearance of the epiphyses in the affected arm is delayed as compared with those of the unaffected arm. Furthermore, there is a distinct lag in their growth. Except in the very severe cases there is little demineralization but rather a delayed growth of bone of fairly normal structure. This is particularly true of the moderate cases where there is often vigorous though, of course, impaired use of the affected arm. These considerations make us doubt whether disuse is so much a factor as the injury to the nerves.

Physical Findings. We have already mentioned that it is the secondary pathologic changes which lead to the characteristic physical findings on which we base our diagnosis and which furnish indications for treatment. In the very earliest cases there is practically only one finding and that is nonfunction of the affected member. There may be swelling in the supraclavicular space and pressure there or attempted passive motion of the arm will elicit evidence of pain. The findings seen later develop slowly and differentiate the cases into different types. These types are as follows:

1. Severe or total type.
2. Moderate type.
   (a) Upper arm (Erb's paralysis)
   (b) Lower arm (Klumpke's paralysis)
3. Slight type.

Of course there is no sharp line of demarcation between these types and there is very frequently a combination of the upper arm and lower arm types without a total paralysis.

Severe Type. The physical findings in this case are primarily a flail arm hanging in the neutral position. All the muscles being affected, there is no distortion. The shoulder joint is usually lax and subluxated downward due to the weight of the arm, which drags on the capsule and the toneless muscles and acts on the shoulder joint. Atrophy of the muscles is marked and involves all groups. The skin is glazed, thin, usually somewhat reddened from the sluggish circulation. There is very little contraction or deformity, the only one commonly seen being flexion of the mid-phalangeal joints seen in the *main à griffe* following median nerve injury. The elbow joint has usually lost the carrying angle and is straighter than normal. X-ray shows the bone smaller, usually demineralized, and with very thin cortex. Fortunately these severe total cases are rare.

Moderate Type. By far the majority of cases fall into this class. Whether a case is of the upper arm or lower arm or mixed type depends solely on the extent of the injury. The classical description in these moderate cases is the arm held in the position of an adducted and internally rotated shoulder joint, slightly flexed wrist and fingers. The muscles affected are the external rotators, shoulder abductors, supinators and extensors. These are all supplied by the branches of the fifth and sixth cervical nerves.

Skin and other trophic changes are not marked in this type except that the arm, especially the upper arm, is shorter than

FIG. 1. Delayed epiphyseal development on the affected arm in brachial palsy. The scapula is also smaller.

the unaffected side. This shortening is actual, not apparent, and, as we have already mentioned, comes from the lag in epiphyseal development. The disability in these moderate cases arises from the fact that the weakness of the abductors and external rotators makes it impossible to swing the arm overhand or to reach the top of the head. Even reaching the face is very awkward, usually being accomplished by elevating the elbow high in the frontal plane of the body and bringing the hand down to the face. This is entirely due to the inability to rotate the humerus externally enough to keep the hand away from the body. The deltoid is practically always affected in birth palsy of the upper arm type, but it is not completely nor evenly paralyzed.

If one observes the shoulder motion in these moderate cases it is found that the anterior portion of the deltoid is usually of good power, while the posterior portion arising from the spine of the scapula is paralyzed. In the normal shoulder the deltoid acts in two portions separately—the anterior or clavicular portion elevating the elbow forward in the sagittal plane, while the posterior portion is relaxed, taking no part in this motion. In brachial palsy this motion is usually preserved. Direct abduction laterally from the body, however, is

usually lost, apparently because of the loss of the posterior position of the deltoid which acts strongly in this motion. The

FIG. 2. Improved abduction and external rotation splint. The bar prevents forward movement of the elbow. The humeral head is held forward in the glenoid.

posterior portion also has a secondary action as an external rotator of the humerus. These varied actions of the deltoid should be kept clearly in mind as they have an important relation to the treatment.

Associated with and following the internal rotation contractures there is a tendency to develop a posterior subluxation of the humeral head. This is accentuated by the paralysis of the infraspinatus and teres minor which reinforce the posterior wall of the capsule of the shoulder joint. This subluxation backward still further complicates matters by rendering the fulcrum against the glenoid cavity very unstable. In the moderate cases there is frequently some flexion contracture at the elbow joint. Occasionally the head of the radius is dislocated upward from its normal position. A moderate pronation contracture is also common. These cases of moderate severity are much more frequently seen than the severe.

Treatment. Every baby delivered, especially where any difficulty has been experienced, should be observed carefully for any evidence of obstetrical paralysis. The evidences are not slow in appearing and any inequality of use in the two arms, particu-

larly if there is apparent pain on passive motion of one arm, should lead to a suspicion of nerve injury. The injury may

tive, hence his judgment is bound to be biased.

One must admit that since the primary

FIG. 3. Models showing method of deltoid transplant. A, portion of deltoid freed from acromion. B, portion of deltoid inserted into spine of scapula.

be mild and the recovery rapid but it should not be overlooked. The first indication to be met in treatment is to remove the stretch from the nerve cords. This is accomplished by elevating the shoulder so that it will approach the ear on the same side and fixing it in that position. This is usually accomplished by abducting and externally rotating the shoulder and flexing the elbow so the forearm is above the head. In this position there is the greatest possible "slack" in the cords of the cervical plexus. This position may be retained in many ways. A strip of aluminum extending from the waist to the elbow and bandaged on is effective if care is taken in handling the infant. Fastening the wrist and hand to the head of the crib is also effective, while the infant is lying on its back, but the arm must not be allowed to dangle when the child is taken up for nursing or bathing. Massage, especially in the region of the injury, is contraindicated. The only surgery at all to be considered in the early cases is exploration and repair of the cervical plexus. Personally I do not feel competent to pass judgment on this procedure since I have never had the opportunity to follow up the cases. The orthopedic surgeon sees only those cases on whom the exploration and repair have not been effec-

pathology is found in the cervical plexus it seems logical to attack it fundamentally. Yet the surgery of nerves is so uncertain even in the most skilful of hands that only those trained in its finer details should attempt it. In such hands an attempt at repair seems the most fundamental attack on the problem, but ordinarily the cases are not seen at the time when such repair would be most effective. Other measures must be used in most instances.

The first indication to be met is the prevention of deformity, particularly the contracture in adduction and internal rotation. This is usually accomplished by the use of some form of brace. The brace to be thoroughly effective should hold the arm externally rotated and abducted laterally. The external rotation is easily controlled but to keep the shoulder abducted directly laterally is not so easy. There is always a tendency for the elbow to be carried forward and if this occurs it is difficult to prevent posterior subluxation of the humeral head from developing. Our bracemaker at the Shriner's Hospital has worked out a brace which is more effective in holding the shoulder forward than those ordinarily used. The use of a brace does more than prevent deformity as we see it. After a period of brace support and

immobilization there develops a certain amount of stiffness in the shoulder joint due, we believe, to general contracture and

physis and we have seen several crushed or slipped epiphyses from manipulation. If there is a beginning subluxation, at-

Fig. 4. K. S. A, in 1933, showing limitation of external rotation. B and C, in 1938, five years after deltoid transplant. External rotation and abduction improved.

fibrosis of the capsule. This serves partially to fix the joint in a favorable position and a good functional result is obtained though not always a brilliant cosmetic result. At any rate our most successful cases from a functional standpoint have been those in which this tightening process—by no means an ankylosis—has occurred. It does not occur if the humeral head is allowed to slip backward in the glenoid cavity.

To sum up, in our opinion the use of a brace is primarily to prevent the posterior slipping of the humeral head and this it must do. In cases when contractures have developed the question arises as to how they are to be dealt with. As has been said, the contracture most frequently developed is that of the internal rotators, particularly the subscapularis and the pectoralis. In our experience if the contracture is of more than minor degree it is practically impossible to release it by manual stretching. The leverage is such that the force is exerted principally on the humeral epi-

tempted stretching tends to increase it rather than elongate the contracture. In these cases the most direct and effective attack is the operation devised by Sever in which the tendon of the subscapularis is divided. After the release of the contracture the arm is retained in the externally rotated and abducted position until healing is well completed, when exercises are begun. It is necessary following this operation that the head of the humerus should be held well forward in the glenoid cavity to provide the maximum release of the contracture. The Kleinberg operation frees the periosteum from the upper portion of the periosteum and rotates the bone inside the periosteal tube into a position of external rotation.

Putti, Hibbs and others have performed osteotomies of the humerus at various levels and have rotated the lower fragment to outward rotation. These operations fall into two classes. The Sever operation releases the contracture while the others

change the relation of the bone to the contracted internal rotators, thus relieving the effect of the contracture. The Sever

intact acromial and clavicular division of the deltoid into an external rotator by shifting its origin backward to the spine of

Fig. 5. J. R. A and B, in 1933. Marked limitation of lateral abduction and external rotation. C and D, in 1938, five years after deltoid transplant. Increase in motion. No subluxation.

operation is effective where subluxation of the head has not occurred, particularly if the head is retained well forward in the glenoid and if the posterior portion of the capsule is firm and strong. Otherwise the contracture may recur to some extent. The Kleinberg operation or one of the osteotomies of the shaft is more effective where subluxation of the humeral head with accompanying stretching of the posterior capsule has taken place, and, of course, contracture does not recur since it has already taken place.

Another line of attack is by attempting to restore muscle balance between the internal and external rotators as exemplified in an operation devised by l'Episcopo and one devised by the author. L'Episcopo, after relieving the internal rotation contracture, transplants the tendon of the teres major to the outer side of the humerus, thus transforming it from an internal to an external rotator. The author attempts to transform a portion of the

the scapula as far as possible, to replace the paralyzed posterior deltoid. The idea originated from observation of a "freak" case of obstetrical paralysis in which the posterior portion of the deltoid had been spared while the anterior portion was paralyzed. In other words in this particular case the usual findings were reversed so far as the deltoid muscle was concerned. This case showed none of the internal rotation contracture and no subluxation of the humeral head. Lateral abduction was lacking and forward abduction was limited to about 45 degrees and was accomplished by the pectoralis major. However, on the whole this case seemed to us to have less disability than the usual type we have described. Certainly bringing the hand to the face and mouth was much less awkward than usual. The operation we have been using was an attempt to imitate this case just described. The operation has been done on fourteen patients from 1931 until the present time. Recently—within the

past few weeks—six of the earlier cases were reëxamined critically and the results studied. It was this critical study which lead to the remark in the opening paragraph of this paper.

We have not classified the results as good, fair, or bad, since this seems to us rather meaningless or at least indefinite, but we have tried to make a detailed study of the effect of the transplant and what it has and has not done. In all the cases, if there was an internal rotation contracture present, it was relieved by a Sever operation before the deltoid transplant was done. The transplant has remained attached in its new position and has retained its power of contraction in all cases except one in which the patient was too young. In our later cases we have been taking a larger portion of muscle for the transplant. This necessitates sacrificing some power in the anterior deltoid but the remaining portion, supplemented by the pectoralis major, has been able to abduct the arm forward. The transplant has not increased the lateral abduction function of the shoulder as we hoped it might. In three cases we have supplemented the operation by transplanting a portion of the trapezius into the greater tuberosity of the humerus, as described by Haas for paralysis of the deltoid. In one case this gave complete lateral abduction against gravity, in another, a smaller increase of function, while the third is too recent to be sure of. The transplant acts as an external rotator when the shoulder is abducted forward or only slightly abducted laterally from the body. This external rotation is not with the full power of a normal shoulder, but is sufficient to permit much easier reaching of the hand to the face. The deltoid transplant will *not* correct subluxation of the humeral head from the glenoid. As a matter of fact any marked degree of subluxation will decrease the effective action of the transplant because of the instability of the fulcrum afforded by the joint. As we see it, this instability of the shoulder joint is the main difficulty in overcoming the effects of birth palsy and is one which we have not yet solved to our complete satisfaction. We believe that the deltoid transplant after release of internal rotation contractures does much to prevent their recurrence, but this point is difficult to prove definitely. We feel that a subluxation of the shoulder joint is at least a relative contraindication to the deltoid transplant operation.

SUMMARY

We stated at the beginning that we hoped to set out the problem of brachial birth palsy even though we have reached no completely satisfactory solution. As we see it, then, it comes down to this:

At the time the orthopedist usually sees the patient the primary pathology is beyond redemption, and he has therefore to concern himself with either prevention (if possible) or correction of secondary pathology. To my mind the most important element in this is the subluxation of the shoulder joint rather than the contracture, though the two go hand in hand. The contracture can easily be dealt with, but if there is also subluxation of the humeral head there is still a very unstable base for the available muscle power to act upon.

In the earlier cases the prevention of these secondary pathologic changes is in order. This is usually done by a brace holding the shoulder abducted to a right angle (*not beyond*) and externally rotated. It must be borne in mind, however, that a splint has no volition of its own and it is up to the surgeon to see that it is doing what he wants it to. We would add that the splint must be so designed and fitted that it not only holds the arm in abduction and external rotation but also holds the humeral head forward and in close contact with the glenoid. Otherwise it will not prevent deformity.

If prevention measures do not achieve the desired result, then operative measures are in order. As to the choice of operation, it will vary with the individual cases. In general we feel that the Sever operation releasing the contracture gives better

SPONDYLOLISTHESIS: SUGGESTIONS FOR TREATMENT

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FOR many years attention has been focused on the subject of low back pain, and the ever increasing interest is readily appreciated when one considers the disability and consequent loss of earning power which ensues, together with the constant drain on the resources of insurance companies which has resulted from the plea of etiologic trauma. Radiology has helped considerably in the differentiation of the various causes of the pain, but it is only in recent years that more accurate observation and knowledge have resulted in the more frequent diagnosis of spondylolisthesis as a separate entity in the causation of this troublesome symptom.

Killian, in 1852, gave the name *spondylolisthesis* to a deformity produced by a gradual gliding or slipping forward of the vertebral column on the sacrum or on the fifth lumbar vertebra. The deformity may be defined as a forward subluxation of the body of the fourth or fifth lumbar vertebra, together with the superimposed vertebrae, on the vertebra below or on the sacrum. In the cases seen by the author the vertebra most commonly displaced has been the fifth lumbar, and only slightly less frequently the fourth lumbar vertebra. Although a similar condition has been described at other parts of the column he has not had personal experience of this.

The displacement varies from one that is only recognizable, to such an extreme degree of dislocation that the displaced vertebra is actually situated in front of the first or second, or even the third, sacral segment. The displacement is usually accompanied by some degree of rotation on a horizontal axis, so that the normal upper surface may eventually look directly forwards.

The term *spondylolisthesis* is, of course, not used for those dislocations which result from acute trauma, tubercle or other infections, and tumors of bone, but only for a gradual process without evidence of disease.

Incidence. At one time spondylolisthesis was rarely discovered except as a cause of difficult labor and, indeed, the most elaborate treatise written on the subject was that of an obstetrician—Neugebauer of Warsaw—who believed that the deformity was related to the female sex only. It is now evident that it is even more common in males. Until 1900, 125 cases had been reported in the literature and all but six by obstetricians; but in twenty-three years in the Mayo Clinic, 207 cases were reviewed of which 71 per cent were males. As a criterion of the increased frequency of the condition, two cases were seen at the Mayo Clinic in 1918, while in 1931 forty-six were reported.

Patients complaining of the symptoms of spondylolisthesis are usually middle-aged, but many appear to have had backache most of their life. The youngest patient on record was 5 years of age, while the oldest, was 80.

Etiology. Such a variety of causes has been put forward to explain this interesting deformity that it would appear that either the true cause is unknown or there may be more than one single factor in its production. A mere tabulation of the causes from the literature would fill several pages, but many of them bear a similarity and they may be classed in three groups: (1) a developmental anomaly; (2) trauma; and (3) arthritis. Increasing experience tends to confirm the opinion that spondylolisthesis is primarily the result of a congenital cleft in the laminae of the neural arch and

this has been a constant finding in every specimen of spondylolisthesis studied. The break in the continuity of the bony neural arch occurs between the superior and inferior articular processes of the lumbar vertebra and releases the body of the vertebra with its superimposed column which together slip forward.

The Primary Congenital Anomaly. A typical vertebra ossifies from three primary centers and five secondary centers. The three primary centers are situated in the body and in each half of the vertebral or neural arch, and the five secondary centers appear at the tip of the spine, the tips of the transverse processes, and the upper and lower surfaces of the body. The primary centers for the arch appear at the roots of the articular processes, and from them the arch and its processes are ossified and also the posterolateral parts of the body—the parts of the body which, in thoracic vertebrae, articulate with the ribs. An important variation in ossification occurs in the fifth lumbar vertebra, which may have two primary centers in each half of the arch, the two parts of each half being united by a plate of cartilage set obliquely between the superior and inferior articular processes. The posterior part of the arch of the fifth, comprising the spine, laminae, and inferior articular processes, is occasionally separated from the rest of the bone owing to non-fusion of the two anomalous centers, union during life being effected by hyaline cartilage. The same condition may be seen in the fourth.

Because of the evolutionary change from the horizontal to the upright position, and the late closure of the neural arches, the lumbosacral joint and the fifth lumbar vertebra are the sites of more anomalies than any other part of the spine. Spina bifida occulta, separate neural arches, and sacralized transverse processes are examples of such congenital abnormalities, but it is those cases in which the whole of the posterior segment, including the inferior articular processes, laminae and spinous process have failed to fuse to the anterior

segment which are of interest in this discussion. This abnormality, where the whole of the posterior segment of the vertebra is separate, is most common in the lumbar region but has been described in the first sacral vertebra by Sandifort, and in the cervical and thoracic region by Neugebauer, who has also described it in the third, fourth and fifth lumbar vertebrae of one spine.

Willis found a separate neural arch in seventy-nine out of 1,520 human skeletons that he dissected, i.e., in more than 5 per cent. He found that at the seventh or eighth week a single center of ossification appeared in each half of the neural arch near the base of the superior articular process. This extends forward to the body, with which it does not fuse until the fourth or fifth year, and backwards to the transverse process, lamina and spinous process. He found that in strong transmitted light there appeared to be two separate areas of dense bone in each half arch connected indefinitely by a narrow isthmus just distal to the developing superior articular process. Serial sections showed that these dark areas were centers of ossification made up of young bony trabeculae. From the anterior expansion developed the anterior part of the half arch, from the posterior, the lamina, inferior articular and spinous processes. Willis found that the two centers are connected by a neck so small that it appears in only one-sixth of the serial sections, while the expansions are cut by nine-tenths of them. In those sections which do not cut the isthmus there appear to be two centers for each half arch. Since true ossification follows invasion by blood vessels, it is certainly possible that as the artery divides at this point into ascending and descending branches, either before or after entering the bone, bone development may progress in a similar manner, and, expanding out in both directions, be defective centrally. Embryologically, therefore, this defect falls into the category of anomalous ossification, of which there are many other examples scattered over the

skeleton. It is peculiar to the lumbar region and may be found in any lumbar vertebra, although usually confined to the last.

It would appear, therefore, that a congenital origin is the probable explanation of the separate neural arch, in spite of possible weakness in the embryologic evidence.

However, a separate neural arch does not necessarily mean spondylolisthesis, as Brailsford has shown. He has figured two instances of dissected specimens showing a separate arch without evidence of fracture and without evidence that spondylolisthesis had occurred. But it is in those cases in which the whole of the posterior segment, including the inferior articular process, laminae and spinous process, has failed to fuse with the anterior segment that the possibility of displacement has to be considered.

If this congenital error be the primary factor in the etiology of a spondylolisthesis, what are the secondary factors which initiate the displacement and consequent deformity?

Normally the tendency to forward displacement of the fifth lumbar vertebra, produced by the shearing strain at the lumbosacral angle, is prevented by the anatomic locking or clamping together of the fifth lumbar vertebra and first sacral vertebra through the coaptation of their articular processes. But if any solution of continuity be present, as in the separate posterior segment described, displacement may occur owing to the superincumbent weight acting as a shearing strain. This slipping will affect only the anterior part of the fifth lumbar vertebra, there being no real locking of the interarticular joints. Under normal conditions this narrow part of the last lumbar vertebra—well named by Chandler the *isthmus*—is subjected to extreme forces. Situated at a critical point at the junction of a mobile and immobile part of the spine, in an area obviously designed for the quadrupedal, and which has undergone little modification since the transition to the vertical position, it

becomes unbelievable to what stress it may be subjected when the normal strain of weight-bearing is increased by motion,

FIG. 1. The ossification of the vertebral arch.

leverage and muscle spasm resulting from sudden strains or falls. The normal isthmus of intact bone may withstand this shearing force, but it is likely that when there are two secondary centers here the strains prove too much and a gradual solution of continuity is produced by the summation of stress and strain of the trauma of normal childhood. Brailsford suggests that the trauma may be at a "very early age" and may even occur at childbirth from a mother with a deformed pelvis. He says that while spondylolisthesis in the mother leads to difficulty in childbirth, difficulty in childbirth may lead to spondylolisthesis in the child.

Whether we accept this theory or not, it is not unlikely that displacement is initiated before the age of 10, for it is about this period that fusion of the two centers in question takes place. Until this time a comparatively weak union exists between these important components of the vertebrae, the strength of which preserves the integrity of the spinal column. If for any reason a severe strain is put on this isthmus, either from nothing more than excessive weight in a rapidly growing

child, or the sudden severe strain of trauma, or even the summation of strains from some particular game or occupation,

Fig. 2. The appearance of spondylolisthesis.

it is not unreasonable to suppose that there may occur here a condition of affairs analogous to what occasionally happens in the hip joints of children at a later age—a slipping or separation of an abnormal epiphysis.

Such a theory, too, would explain those cases where the lumbar body has been described as elongated anteroposteriorly; for a slipped epiphysis does not necessarily mean a complete solution of continuity, but may appear only as a stretching of the actual cartilage, which may later ossify and hold the body in a position which, though displaced forwards, becomes stable since the arc has become united. If the separation is complete, then the stage is set for a complete spondylolisthesis. However, this will probably be a slow process as in the young child the subsidiary factors of anterior spinal ligaments and interspinous ligaments may hold the parts for years. These ligaments slowly lengthen, however, and the body continues to slip. With displaced body and stretched ligaments, pain inevitably supervenes, and a later trauma may cause a further stretching and dis-

placement. It is probable, therefore, that in many cases this trauma is of considerable etiologic importance.

In spite of the fact that the supports of the spondylolisthetic fifth lumbar vertebra are insecure, the displaced body may come to a final position of rest after making only a moderate forward movement. Natural arrest is favored by several factors. One of these is the iliolumbar ligaments, slanting from the transverse process of the vertebra to the iliac crest. The restraining influence of these ligaments is aided by the tendency of the pelvis to assume a more vertical position by rotation on its transverse axis. Bone often proliferates on the anterior surface of the sacrum beneath the displaced portion of the fifth lumbar vertebra, forming a buttress of sufficient strength to prevent further slipping.

The Clinical Picture. Generally there is a history of single or repeated trauma, but this is by no means constant and often no history of injury can be elicited. The patient's first complaint is of pain in the lumbar region, coming on usually about puberty, but sometimes initiated by parturition. The pain is at its maximum in the lumbar region and radiates down the legs. It is made worse by prolonged standing, especially in the bending position as in washing, by the carrying of heavy objects, and by any exercises which entail mobility in the lumbosacral region. It is relieved by rest. The pain is frequently of a very severe nature and in a recent case even walking had to be curtailed to a minimum and yet, in spite of limitation of physical exertion, the patient's face showed the evidences of her long suffering.

On examination the profile of the patient is the most striking feature. The trunk appears to be shortened, as it must be because the spine is telescoped into the pelvis. Encircling the trunk, just below the rib margin, is a well marked and often deep skin crease. This is seen on both sides behind and sometimes folds of the skin project down over the pubis. The rib margin approaches the iliac crest and the

distance between the xyphoid and the pubis is reduced. The sacrum is more prominent than usual and has been described as "superficialized."

Just above the prominent sacrum the spinous process of the last lumbar vertebra can be felt. It is much more prominent than usual, and this prominence is further exaggerated by the presence of a definite hollow, easily recognized by inspection, in the lower lumbar region. Above this hollow the spinous processes have the normal arrangement. The difference between the aggravation of a normal lordosis and the lordotic hollow of spondylolisthesis can easily be appreciated as the slipping of the vertebra produces an angulation rather than a curve. The normal pelvic tilting is diminished and the anterior superior spines are therefore apparently rotated backwards through a sagittal arc. The prominent vertebra produces diminution of the anteroposterior diameter of the pelvic inlet, often forming a formidable obstruction to parturition. Not infrequently the patient has a waddling gait, with the legs rather far apart, but this has not been noticeable in any of the author's cases. In spite of a somewhat stiff carriage of the body with a slight backward inclination of the trunk, forward bending has always been accomplished to a remarkable degree. The slipping of the displaced vertebra may become unequal, and when that is so a slight degree of scoliosis results. A slight difficulty in hyperextension of the hip joints has been noted, due no doubt to the rotation of the pelvis. The lumbosacral and sacroiliac joints are not uncommonly tender, but in this there is no point of diagnostic importance.

On abdominal examination, especially when the colon is empty, it may be possible to palpate the protruding body of the displaced vertebra forming a projection into the pelvis below which the fingers may slip into the pelvic cavity. Neuralgic signs are usually absent, although pressure on the branches of the cauda equina may occur and pain be produced in the sciatic distribution. In one of the cases seen by the author the principal pain was located in the dorsal region which was the subject of an exaggeration of the normal lordosis. It is realized now that this was an important sign described first by Tchirkin of Warsaw. He pointed out that the tilting of the pelvis produced a compensatory forward bend of the spine in the region between the flexible lumbar and rigid dorsal vertebrae. Tchirkin believes this sign to be pathognomonic of the clinical picture of spondylolisthesis of recent origin.

The X-ray Appearance. Although the diagnosis may be fairly presumed in a well-marked case after clinical examination, there can be no certainty without good anteroposterior and lateral x-rays of this area of the spine.

1. *The anteroposterior view.* The displaced body rotates on a transverse axis, so that an anteroposterior radiograph shows the displaced body overlying the upper border of the sacrum. The lower outline of this shadow is really the anterior line of the transverse processes and body of the vertebra, so that the characteristic arc, or bow, is seen. It is to be noted that this is not pathognomonic, as it may occur in a prespondylolisthetic case, and indeed may be present when there is nothing more than an exaggeration of the lumbosacral angle.

In certain cases the superoposterior part of the vertebra can be seen to give a curious inverted Y-shaped shadow on the antero-posterior x-ray. A comparison of the bicristal and bitrochanteric lengths with the normal is of some diagnostic importance. Neugebauer pointed out that normally the bitrochanteric length—the greatest distance between the great trochanters with the legs lying side by side—is slightly greater than the bicristal length—the greatest distance between the iliac crests. This sign of Neugebauer's can be determined more accurately from radiographs than by clinical methods.

2. *The lateral radiograph.* It is from this view that the diagnosis can be made. The forward displacement is evident, and varies

in degree from negligible to complete, so that sometimes the displaced vertebra may be lying in front of the vertebra below or

FIG. 3. The anteroposterior view showing the typical arc, the y-shaped fragment, and the slight scoliosis.

even in front of two below it. Ullman's sign is demonstrated by drawing a line upwards at right angles from the anterior edge of the superior surface of the first sacral vertebra. This line cuts through the last lumbar vertebra in cases of spondylolisthesis.

Neugebauer showed that there is an anteroposterior elongation of the abnormal vertebra, in that the distance between its posterior end (spinous process) and its anterior end (front of the body) is greater than the corresponding measurement of the neighboring vertebra. The most characteristic feature of the lateral view, however, is a break in the laminae. This appears as a gap continuing the lumbosacral intervertebral clear space backwards above the spinous process of the fifth vertebra.

In older cases an attempt is made by nature to arrest the displacement by the formation of a bony buttress from the front of the sacrum under the projecting portion of the displaced vertebra.

Differential Diagnosis. Tuberculous caries of the spine may be confused owing to the localized type of deformity. As a rule,
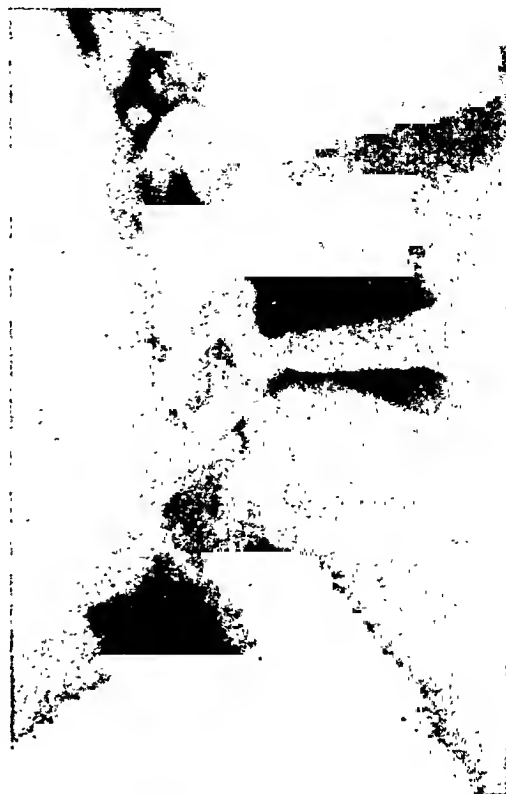
FIG. 4. Lateral view, showing break in the lamina, anteroposterior lengthening of the displaced vertebra, commencing buttress formation, and extent of displacement.

with tubercle, pain is a prominent early symptom, often occurring before any sign of deformity; whereas with spondylolisthesis pain is a less prominent feature. The prominence of the sacrum is not observed in tubercle, while a radiograph should give conclusive evidence.

Brailsford mentions two conditions which may be misinterpreted as spondylolisthesis on examining an anteroposterior radiograph:

1. *Acute lumbosacral angle.* The plane of the anterior surface of the upper body of the sacrum is almost at a right angle to the plane of the anterior border of the lumbar body.

2. A normal lumbosacral angle associated with *ossification of the attachment of the anterior common ligament* to the superior

border of the sacrum. A faint concentric line may be seen in these cases across the first sacral body.

Both of these conditions, however, may be easily recognized on taking a lateral view.

Some lateral radiographs are confusing.

Pseudo-spondylolisthesis. Brailsford shows a lateral radiograph showing obliteration of the outline of the anterior surface of the fifth lumbar by denser shadows of the anterolateral borders of the ilia. The posterior surfaces are in normal alignment however.

Osteomalacia of the pelvis. The first sacral vertebra shows the outline of its superior surface on the pelvic brim markedly deformed and contracted.

Treatment. The treatment must be directed to supporting the displaced vertebra in such a way that the abnormal stretching and tension on the attached ligaments is prevented. It might be supposed that an attempt should be made to reduce the subluxation, but on exposure of the condition at operation it is evident that in the great majority of cases such an attempt would be doomed to failure. The space from which the vertebral body has slipped is quickly closed by fibrous tissue of such density that it is not likely that the strongest traction will pull down the sacrum to allow replacement, nor is it likely that manipulation will be any more successful. Nevertheless, attempts have been made to reduce the deformity by traction with the spine and hips flexed to reduce tension and spasm, and also with the same joints hyperextended in attempts to open up the abnormal space. In none of the cases was there the slightest suggestion, even after a few weeks, that this would be successful.

As there are patients who have a spondylolisthesis without any symptoms it follows that there are degrees of severity of the condition. Indeed, Meyerding has classed them in grades according to the extent of the displacement; but it is rather to the grades of severity of symptoms than to the grades of displacement that attention should be directed. Recently a case was seen at an obstetric hospital where a "curious deformity" of the pelvis had attracted the attention of the accoucheur. The x-ray showed a very extreme forward displacement of the fourth lumbar vertebra on the fifth lumbar vertebra and yet there was no history of symptoms and there had been no difficulty in the labor. There is no doubt of the fact that it was the higher site of the trouble which allowed of normal delivery. The notable point, however, was that here was an extreme deformity and yet the woman had no history of suffering.

So the mere discovery of a spondylolisthesis does not indicate a major operation, and though there may be a temptation to prevent the development of the dislocation, the treatment in the first instance, if any treatment be indicated, should be that of any postural backache—the prohibition of any strenuous occupation or exercise likely to accentuate the tension on the ligaments; a period of rest; and the provision of some type of supporting brace in certain cases. One can be quite certain that the backache will be cured by rest and remain so as long as the rest is enforced. Most of the patients are well aware of this fact and find that the most comfortable position is lying flat on the back on a fairly firm bed, though curiously enough some have found the ventral position preferable. Traction and countertraction are often of great benefit in the acute phases as by such method the stretching of the ligaments is released. It is difficult to conceive of any brace that will take the weight of the trunk off the stretched ligaments, as the only counterpressure likely to be effective must be placed anteriorly directed against and supporting the displaced vertebra, and such a pressure is manifestly impossible to achieve. In all probability, therefore, a brace merely acts by limiting motion and thus it is not surprising that a sacroiliac belt is less helpful than a back brace with lateral spinal uprights fitting snugly into the lumbar curve.

Even when such a spinal support does not completely relieve the symptoms, serious consideration must be given to the question of operative treatment before it is carried out. If a lateral radiograph shows a large supporting buttress, or evidence of bony fusion of the displaced vertebra, it is unlikely that an arthrodesis operation will relieve the symptoms. Obese patients are always referred to the dietetic department whatever method of treatment is adopted, and in such cases one hesitates to suggest operative treatment, for these patients do not stand the necessarily prolonged treatment in the dorsal position.

In those who must work, however, and whose physical condition permits, surgery offers the most satisfactory and permanent means of relief. The two possibilities in the treatment of a dislocation are reduction and fixation, and as the former has been shown to be impossible some form of fixation is the only alternative. Spinal fixation immediately suggests the brilliant work of Albee and it is not surprising that all the methods described are based on his work. The arthrodesis may be performed through either a posterior or anterior route.

1. *Posterior Arthrodesis.* Albee believes in an osteosynthetising operation. He states that until the introduction of the spine immobilizing operation, no satisfactory treatment had been devised for the condition. The mechanical features of the bone graft when immobilizing the spine are exceptionally well adapted to this most difficult problem, in that a strong graft, inlaid into the spinous processes of the lower lumbar vertebrae and carefully adapted to the posterior surface of the sacrum affords a firm immobilization with an unusually firm anchorage for the graft. Albee uses an accurately shaped graft, angled at its lower end to fit the lumbosacral junction. He anchors it into the split spinous processes of the two vertebrae above the displacement, the lower end of the graft being carefully fitted to the posterior surface of the sacrum. Albee believes that there is a tendency for the old

deformity to relapse and for the lumbar vertebrae to sag forward, but that this remedy forces the lower end of the graft more firmly against the posterior surface of the sacrum! There is therefore, he says, fortunately not the same necessity for as firm an inlay anchorage in the sacrum as there is in the case of the vertebrae. Meyerding uses a somewhat similar method, but obtains fusion by double massive grafts and multiple chips of cancellous bone. He attempts to fuse the third, fourth and fifth lumbar vertebrae with the sacrum.

In the consideration of this type of operation one is inclined to agree with Capener who states that bone grafts undoubtedly assist many patients, but it must be remembered that high posterior bone grafting does not possess a great degree of efficiency from a mechanical point of view. Tremendous forces are brought to bear on the graft, which, in any case, has no direct connection with the body it proposes to prevent from slipping. In the last case seen by the author this operation had been performed on two occasions and following each operation the graft had broken opposite the site of the slipping vertebra. In cases with sacral spina bifida, which are not unusual, it is difficult to obtain fixation for the graft at the lower end.

2. *Anterior Methods.* 1. Capener remarks that the ideal operation would be either an anterior bone graft so placed as to fix the body of the fifth lumbar vertebra to the sacrum and form a buttress, or some form of anteroposterior fixation of the two halves of the divided vertebra. He shows a diagram of his theoretical alternative to the posterior bone graft operation. A peg is driven in anteriorly from the front of the body of the fifth lumbar vertebra down and into the middle of the sacral body, while another peg is shown driven from the inferior articular facet on the posterior free segment of the fifth lumbar vertebra, forwards through the superior articular facet and into the body of the fifth lumbar vertebra. He states, however, that the

technical difficulties of such procedures preclude their trial.

2. Burns has described a method of

view of this he suggests for his subsequent cases a steel pin.

There is apparently a tendency for
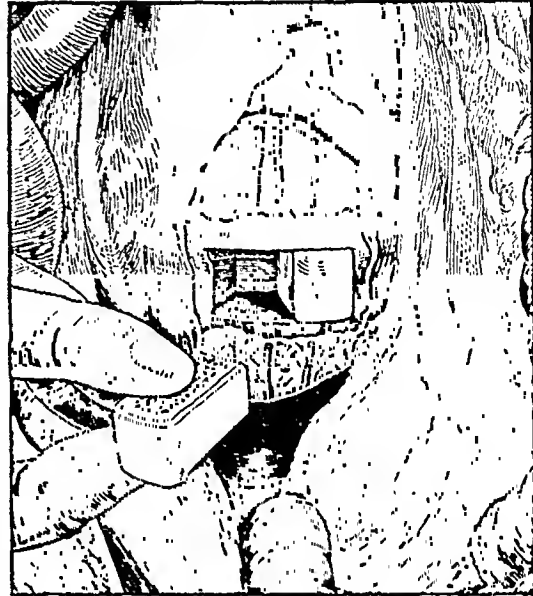
FIG. 5. A, exposure of operation area and enplacement for graft. B, grafts being placed in position. (Vessels and nerves are not so ruthlessly divided.)

pegging the bodies of the vertebrae from the front. The abdomen is opened by a left paramedian incision with the patient in the Trendelenburg position. The intestines are packed off and the anterior aspect of the fifth lumbar vertebra exposed by incising the posterior parietal peritoneum, and cleared by blunt dissection, the left common iliac vein being retracted upwards and carefully guarded. A hole is drilled almost vertically downwards through the body of the fifth lumbar vertebra and through it a tibial graft is driven with a punch. Burns believes that the hammering entailed may produce a partial reduction, or at any rate an improvement in the dislocation. He believes it not unlikely that the graft may be absorbed, as he thinks the intervertebral disc is not an ideal situation for a graft. In

extrusion of the peg from the vertebral body to occur and in one case concurrent absorption of the peg was noted, no fusion of the displaced body taking place.

3. In view of the unsatisfactory outcome of other methods, the author has attempted, experimentally in the first place, to operate from an anterior approach. There are, of course, objections to such an approach, but the fourth and fifth lumbar bodies are by no means inaccessible by this route in spite of the many sympathetic nerves and small vessels encountered. The presacral plexus is liable to injury; to minimize the damage a straight vertical incision is made and the various small structures carefully swept laterally, any small vessels being tied. It was found in an experiment that after the graft had been hammered into position it

was very easily displaced by transport of the cadaver with the hand supporting the lumbar curve. This tended to extend the

nerves and the fibrous fatty tissue are swept laterally with a gauze swab. The type of operation will now depend upon
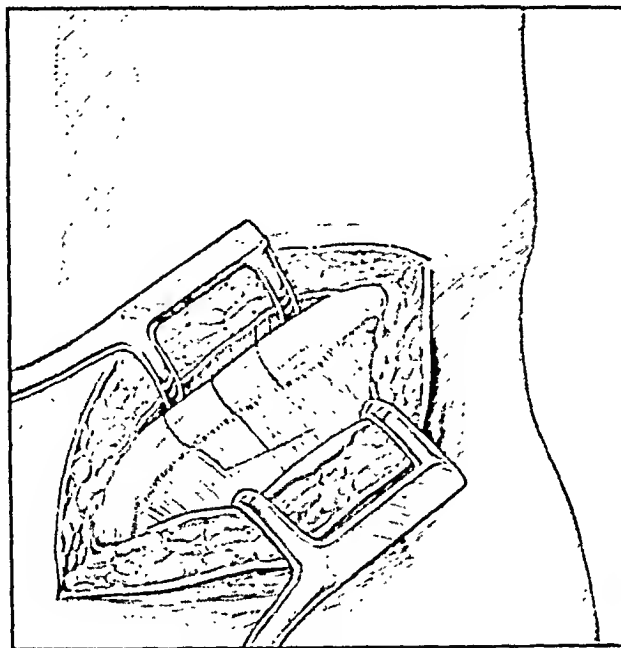
Fig. 6. Removal of the grafts.

neighboring bodies sufficiently to loosen the graft. Accordingly it is better to do the operation with the patient in a plaster shell in order that the spine may be completely immobilized afterward.

In one case the patient developed a mesenteric thrombosis. This, however, is no doubt a preventable complication and may have been due to trauma at the time of the operation.

The Method. With the patient lying in a posterior plaster shell the table is raised at its lower end and an exaggerated Trendelenburg position produced. A long midline incision is made, extending to above the umbilicus. Most of the abdominal contents are displaced by the Trendelenburg position and are packed off from the operation area following the insertion of a self-retaining retractor. The deformity is then examined, particularly in regard to its relationship to the iliac vessels. The posterior peritoneum over the vertebra is divided in a vertical direction and the small veins ligated, together with, when necessary, the middle sacral artery. The rest of the small

the extent of the deformity encountered. Where the deformity is not extreme a rectangular hole may be produced with an osteotome by cutting away the lower margin of the fifth lumbar vertebra and the upper margin of the sacrum, along with the intervening part of the intervertebral disc. Autogenous bone grafts are now taken from the crest of the ilium to wedge into the gap. Two pieces are removed, as a single one cannot be obtained broad enough to wedge in position securely. The grafts are hammered tight into the gap and may be screwed into place or nailed with a bone peg. This ensures their retention. The peritoneum is carefully stitched over the grafts and the abdominal wound closed.

The patient should remain in the shell for at least four months and then lie free from restraint in bed for a further month, following which a Goldthwaite brace is fitted.

In those cases where the displacement is extreme it would not be possible to proceed in the above manner, but the suggestion is made that the same access be used and a

vertical rectangular hole made through the lower part of the displaced body into the front of the sacrum, as is shown in the

down the back of the thigh and calf to the heel. There was a considerable degree of stiffness after sitting for any time.
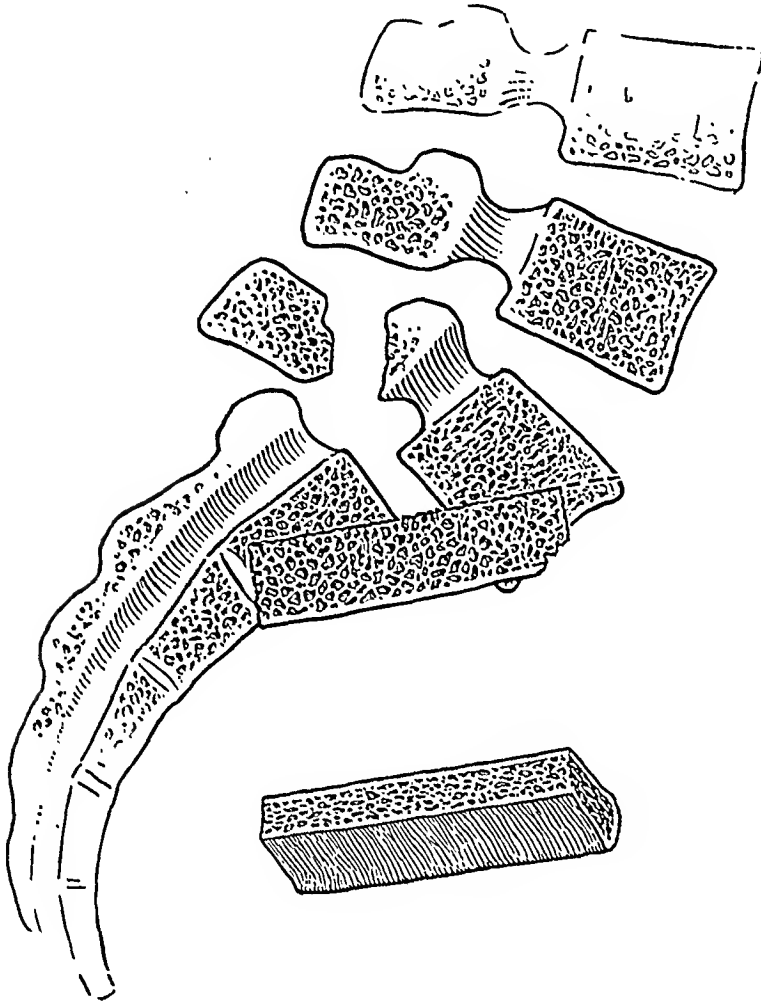
Fig. 7a. Area suggested for graft.

Fig. 7b. Method in profile.

diagram. Although this is admittedly not such a good mechanical proposition as the operation described, it is probably an improvement on a posterior graft which has no connection with the displaced body. An opportunity has not yet occurred for the use of this second method.

Three typical cases are described:

CASE 1.   G. S. (aged 17). This young man complained of pain in the lower part of the back of nine months' duration, and of pain in his legs, especially the right, for five months. The pain came on insidiously and was worst when he stood or sat down for any length of time. It was relieved by lying down, when it disappeared completely within half an hour. Walking also produced relief but there was a curious jerkiness in his gait. The pain radiated
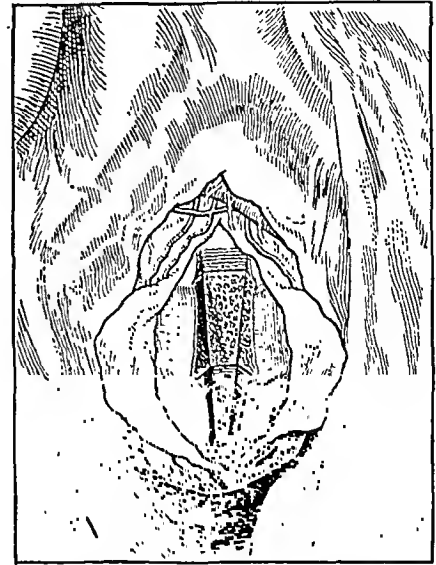
Examination showed all the typical signs of a spondylolisthesis. There was a gross exaggeration of the normal lumbar lordosis accompanied by a slight scoliosis, the convexity being to the right. Flexion of the trunk was limited.

An attempt was made to improve the deformity by putting traction to both lower limbs while the spine and hips were flexed. No improvement resulted during a period of three weeks and accordingly the decision to operate was made. It was decided to attempt Burns's method and this was done through a 10-inch suprapubic incision. The vessels were caught and tied and the intestine packed off and retracted, exposing the peritoneum through which the prominence of the lower border of the fifth lumbar vertebra was visible. The peritoneum was incised, the retroperitoneal structures swept aside by gauze swabs, and the vertebra exposed. A hole was made by

hand gouge to a depth of 2 inches through the body. A second gouge of larger size increased the diameter of the hole. An ivory peg was then driven into the hole for a depth of about 3 inches, apparently entering the body of the first sacral vertebra. This peg was cut off flush by bone forceps and the rent in the peritoneum repaired with catgut sutures. The patient remained in the shell for four months and was thereafter fitted with a Goldthwaite brace.

This particular case was interesting in that nineteen months after the operation the patient had an attack of appendicitis which allowed of examination of the operation area. The operator reported the existence of a projection the thickness of a lead pencil extending for 1 inch in front of the last lumbar vertebra. There were no adhesions in this neighborhood. The projection was left intact.

CASE II.   A. F., a miner, aged 37, had complained of pain in the lower part of the small of the back for the last three years. He stated that a blow in the small of the back from a large stone initiated the low back pain, which was usually dull and gnawing, but intensely sharp on bending forwards. It was intermittent and worse when he had been on his feet or walking for any length of time. It radiated down into both legs and he was very easily tired.

On examination there was a very slight central depression without marked prominence of the spinous process. Lateral skin creases were evident, more marked on the left side. There was no thoracic kyphosis. Telescoping was not apparent. His movements were greatly limited and attempted flexion produced extreme pain. There was no abnormality in his gait. An x-ray showed a forward displacement of the fourth lumbar vertebra on the sacrum.

He was operated on in the manner described by the author, by the anterior method. A back brace was worn for a year but has now been discarded. The pain has completely disappeared. He is able to touch his toes without

difficulty, and he says his back is perfectly well now and he is able to work.

CASE III.   Miss M. F., a bank clerk, aged 42, had suffered from what she called lumbago for ten years. At the age of 10 she fell in the sitting position when a hammock gave away. She now complained of pain at the base of her spine, radiating upwards, round to the front, and to some extent down the outer side of the thigh. It was sharp and shooting in nature and was constantly present, but was aggravated by movement. She had to use a cushion when sitting, the cushion being placed in the small of her back.

On examination there was a marked increase of the normal lumbar lordosis, but there was no listing of the spine nor any degree of limitation of movement. The spinous process of the fifth lumbar vertebra seemed more prominent than the others and there was some evidence of lateral skin creases.

This patient had a posterior graft inserted, uniting the spinous process of the third, fourth and fifth lumbar, and first and second sacral vertebrae. She has been improved by the operation but still has pain and still needs to wear a back brace.

CONCLUSIONS

Spondylolisthesis is a condition which does not occur with sufficient frequency to allow of dogmatic statements or of any conclusions of value being drawn from any particular type of treatment. It is believed that the more efficient way of fixing the slipping vertebral body is by an anterior graft. The difficulties to be overcome are not excessive and suggestions are made for such a method in two types of case. One of the methods described has been carried out with an encouraging degree of success and it is certainly worthy of a more extended trial.

SPINA BIFIDA

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SPINA bifida is a condition which presents in both its frank and its occult forms some interesting problems of reconstruction. The severe type of spina bifida commonly seen in the newborn, spina bifida with a sac involving meninges or cord, demands the immediate attention of the neurosurgeon, and plastic operative procedures in the hands of experts have proved life saving. Frequently, however, further surgical treatment is necessary in these cases to correct deformities and disturbances of function due to primary nerve defects unaffected by the plastic operation upon the spinal hernia. Furthermore, a great group of cases has now been described in which neuromuscular dysfunction on the basis of a spina bifida occulta presents problems for the neurosurgeon, the orthopedist, and the urologist.

CLASSIFICATION

Spina bifida in any of its forms represents a failure of development in fetal life of the neural tube and its coverings. Normally the neural tube separates from the overlying epiblast early in the life of the embryo. At the same time mesoblastic tissue grows in to form vertebral arches and spinous processes between the tissues of the epidermis and the neural tube. When the normal course of development is arrested or perverted, a hiatus in the bony wall of the vertebral canal results, with elements of the central nervous system lying directly under the skin and often attached to it. Various theories have been advanced to account for this developmental defect, but there seems to be no conclusive evidence to support any one concept.

The different types of spina bifida are well defined clinically, although there may be some variation in their terminology. Anterior spina bifida is very rare. Of the posterior variety, three forms are known: (1) rachischisis—the most severe type, in which there is an incomplete closure of the neural canal, the everted lining of the neural tube forming a reddish band down the middle of the back; (2) spina bifida cystica—usually referred to simply as "spina bifida," in which a herniation of central nervous system elements through a vertebral defect occurs; (3) spina bifida occulta—in which a vertebral defect exists, without any visible external malformation of the spinal cord, nerves, or meninges. Spina bifida cystica has been subdivided according to the contents of its tumor or sac. Under this classification are grouped meningocele, myelocele, meningomyelocele, and syringomyelocele. All types of spina bifida occur most commonly in the lumbosacral region.

For cases of rachischisis no surgical treatment is indicated since this condition is incompatible with life. Spina bifida, with a sac-like tumor which contains meninges, nerves, or the spinal cord itself, is best treated by early operation. Cutler, Coughlin, Penfield and Cone, Kolodny, and Gross and Sachs have well described the technique and end results of plastic procedures to repair the spinal herniation. Spina bifida occulta, a relatively common roentgenologic finding, is of significance only when definite evidences of cord involvement, such as muscle paralyses, deformities of the extremities, trophic ulcers, or disturbances of bladder or bowel function are found in conjunction with the vertebral defect. Pathological conditions associated with a spinal cleft and causing mechanical inter-

ference with nerve elements have frequently been relieved by laminectomy.

SPINA BIFIDA CYSTICA

Cases of spina bifida which have had an early plastic repair of a spinal hernia in the lumbosacral region quite commonly present marked deformities and disabilities. Flaccid and spastic muscle paralyses, deformed bones and joints, and sensory, trophic, and circulatory disturbances in the lower extremities constitute serious orthopedic problems in these cases. A great number show deformities of the feet, and these deformities are quite lacking in uniformity. In a group of these cases studied at the St. Louis Shriners' Hospital in 1935, the most common position of deformity was equinovarus, but almost every other type of malformation was represented: equinovalgus, equinovarus with cavus, calcaneovarus, calcaneovalgus, and simple equinus, calcaneus, cavus, varus, and valgus. Frequently the deformities of the two feet are entirely different. A high percentage of these cases show loss of normal sensitivity in the lower extremities; circulation of the legs is poor, and trophic ulcers of the buttocks or feet may be present. Many cases show a tendency to hydrocephalus, and the mentality may be subnormal. Bilateral dislocation of the hip is a not infrequent finding.

Orthopedic treatment is definitely of value in improving the powers of locomotion in cases of spina bifida having from birth an obviously extensive involvement of the central nervous system. While many of these patients have very little muscular power in their lower extremities, they may be enabled to utilize better their available strength by the correction of deformities, lengthening and transplantation of tendons, fitting of braces, and application of physical therapy. In carrying out manipulations or applying wedging plasters in the correction of deformities of the lower extremities, the danger of producing pressure sores in tissues of low vitality should be kept in mind. It is frequently necessary in this group of cases to arthrodese the ankle or tarsal joints in order to maintain the position of the feet after correction. Dislocation of the hip is handled as any ordinary congenital dislocation if the patient's other disabilities are not so extensive as to militate against the shock of reduction procedures. Patients with almost complete paralysis of the lower extremities must be equipped with crutches or walkers.

Paralysis of the vesical sphincter, with obstructive dilatation and infection of the urinary tract (Mertz and Smith) or complete urinary incontinence, is frequently found in cases with extensive nerve involvement, and constitutes a complicating factor in their treatment. Less commonly rectal dysfunction is present. The child with incontinence of bladder and bowel has a very unfavorable outlook, and there are but few possibilities for the relief of these individuals. Uretero-enterostomy is applicable in cases of urinary incontinence alone. The reinforcement of vesical sphincter action by transplantation of the gracilis muscle into the perineum to encircle the urethra is also a possibility (Deming, Player and Callander, Smith and Engel). In cases characterized by a marked urinary retention with overflow, presacral neurectomy, as described by Learmonth and Braasch, would seem to be indicated. After making cystometric studies in thirty cases of spina bifida urinary incontinence, McCarroll has concluded that urinary control can be established in many cases by simple forms of bladder reëducation. He believes, furthermore, that operative procedures are never justified before the age of puberty, since marked improvement in bladder function is possible as the child matures. In his series of cases, the use of large enemas made possible the control of fecal incontinence when this was found associated with a defective bladder.

ILLUSTRATIVE CASES
(St. Louis Shriners' Hospital)

J 51, female, age 4 years. Lumbosacral spina bifida; plastic operation at 2 months. Inconti-

nent of urine and feces; ulcer of buttock; pes equinovarus, right. Treatment: wedging plaster, transplant of anterior tibial tendon to

thetic; pes equinovarus, left, and pes valgus, right, with tibial torsion. Treatment: patient was admitted to hospital for stabilization of

Fig. 1.

Fig. 2.

Fig. 3.

Figs. 1, 2 and 3. Spina bifida cystica. Case G 85 (Shriners' Hospital, St. Louis). Male, aged 9. Lumbosacral meningocele at birth; corrective plastic operation after twelve hours. Spina bifida involving third, fourth and fifth lumbar, and all sacral vertebrae. Appearance of patient before operative treatment, and after bilateral astragalectomy and bilateral arthrodesis of ankle joint. (From Smith, in *Surg., Gynec. & Obst.*, 62: 218, 1936.)

feet. Patient died of pyelonephritis before operative treatment could be carried out.

outer tarsus. Result: excellent correction of foot.

K 28, male, age 12 years. Lumbosacral spina bifida; plastic operation at 3 years. Incontinent of urine and feces; pes cavus, bilateral. Treatment: previous to admission, Steindler stripping of os calcis, bilateral; after admission, triple arthrodesis, plantar fasciotomy, and section of the posterior tibial tendon, bilateral. Result: good correction after eight months.

A 64, female, age 11 years. Lumbosacral spina bifida; plastic operation on third day. Incontinent of urine, diminished sensation in lower extremities, trophic ulcers of feet and buttocks; feet flail, with contractures of hips and knees. Treatment: section of hip flexors; contractures corrected by manipulations. Result: contractures recurred within a year after discharge. Patient is incapable of walking; prognosis poor.

D 44, female, age 9 years. Spina bifida involving all sacral vertebrae; plastic operation in infancy. Bilateral hydronephrosis, with hydroureter. Feet cold, cyanotic, and hypes-

SPINA BIFIDA OCCULTA

Spina bifida occulta probably occurs more frequently than available statistics would indicate. In early childhood incomplete fusion of the laminae of the lumbar and sacral vertebrae is very common (Hintze, Steindler, Neubert), and evidence is accumulating to indicate that in a considerable number of instances these vertebral defects persist into adult life. In roentgenologic studies Wheeler found defects of the laminae of the fifth lumbar vertebra in 2.3 per cent of adults. Roederer and Lagrot, in 1,000 x-ray examinations, found lumbosacral spina bifida occulta existing in one-third of these cases, with the first sacral vertebra involved in one-fifth of the total number. Ellis, who has pointed out the industrial implications of spina bifida acculta, estimates that in adult workingmen a defect occurs in the lumbar spine or sacrum in between 6 and 8 per cent of

cases. Many patients showing a spina bifida occulta are without symptoms, and no correlation can be found between the size of the spinal defect and the degree of disability when there is nerve involvement. Indeed, there exists a group of cases, clinically identical with spina bifida occulta, in which no bony defect can be demonstrated. To account for this condition, Fuchs has postulated a "myelodysplasia," or primary defect in development of the central nervous system.

The variable anatomic findings in spina bifida occulta have been well summarized by Buchstein and Love. The only constant feature is a defective formation of one or more vertebral arches, most commonly the last lumbar or first sacral. The vertebral laminae are absent, foreshortened, or malformed and do not meet in the midline. There is no spinous process. In some cases, the existence of a spina bifida occulta is indicated by changes in the overlying skin. There may be a small dimple over the spinal defect, or a patch of hair, an area of pigmentation, or an area of telangiectasis. In some instances a fibrolipomatous growth will occupy the subcutaneous tissues and cause a slight elevation of the surface of the skin. The defect in the vertebral arch may be open, or closed by a fibrous membrane. This is quite thick, in some instances, and protrudes into the spinal canal to compress the cord. Bands of connective tissue may connect this membrane with the skin or dura, or unite both skin and dura. When there is an attachment to the dura an angulation of the dural sac may be produced, causing tension or pressure on the enclosed cord and nerves.

The nerve tissue itself may show malformations, the most common of which is a fusion of the cauda equina into a single irregular bundle. Hydromyelia, due presumably to faulty closure of the neural tube, has also been described. Some cases may show a local outpouching of the dura, which, if it contains nerve elements, constitutes an occult myelomeningocele. Benign neoplasms, lipomatous or fibrolipomatous

in nature, have frequently been found in conjunction with spina bifida occulta. These may lie extradurally or intradurally, and may be intimately connected with the cauda equina.

A variety of developmental anomalies elsewhere in the body has been found in association with spina bifida occulta. Some of these would appear to be coincidental; for example, syndactylism, hypospadias, cryptorchidism, cleft palate, uterine prolapse, malformation of the ear, absence of the neck of the femur, bladder exstrophy, and hydrocephalus. In the case of others, notably the large group of foot deformities, a cause and effect relationship would seem to exist between the segment of cord involved and the abnormality observed. Congenital dislocation of the hip and lumbodorsal scoliosis occur frequently in conjunction with defects of the lumbosacral spine, but a causal relationship is more difficult of proof in these two conditions.

The symptoms of spina bifida occulta differ somewhat in childhood and in adult life. The disabilities found in cases of spina bifida occulta in childhood are quite similar to those found in cases of frank spina bifida cystica, and may be as pronounced. Every type of paralysis and foot deformity may be seen in association with a spina bifida occulta; sensory, trophic, and circulatory disturbances also may be observed; and dysfunction of bladder and bowel in varying degree is frequently present. In childhood these disabilities are relatively static. In adolescent or early adult life, however, disturbances of function may appear for the first time and defects previously stationary may suddenly assume a progressive character. This circumstance is explained as being due to the application of mechanical tension to a cord unnaturally attached to dura or tumor growth during a period of rapid body development. It has also been suggested that a myelodysplasic spinal cord may be less able to withstand ordinary developmental stresses than a normal spinal cord.

When the existence of a spina bifida occulta is suspected, the diagnosis is easily made. Physical examination may reveal a

Fig. 4.

a congenital nerve defect. Clubfoot, claw-foot and flatfoot are the more common of these deformities. It has been noted that

Fig. 5.   Fig. 6.

Figs. 4, 5 and 6. Spina bifida occulta. Case H 139 (Shriners' Hospital, St. Louis). Female, aged 7. Spina bifida involving third, fourth and fifth lumbar and all sacral vertebrae. Appearance of patient before operative treatment, and after lengthening of heel cord, triple arthrodesis and tibial turn left. (From Smith, in *Surg., Gynec. & Obst.*, 62: 218, 1936.)

betraying dimple, tumor, area of pigmentation, telangiectasis, or hairy growth, but, in the absence of physical signs, the vertebral defect is readily demonstrated by x-ray. The plan of treatment is then determined to a large extent by the history of the case. If the disability has been present from birth and is not progressive, it is probably due to a primary defect of development of the spinal cord. Local or symptomatic treatment, therefore, is all that is indicated. Symptoms which occur at puberty or in early adult life, and are progressive and recurrent in nature call for causal intervention as represented by an exploratory laminectomy, with removal of any lesions causing mechanical interference with nerve function.

The various deformities of the feet found in association with spina bifida occulta in childhood are probably due for the most part to a muscular imbalance secondary to

deformities of the feet present since birth and associated with a persistent spinal cleft are more resistant to treatment than other congenital varieties. Correction of these deformities by manipulation is generally difficult, and operative treatment is usually required. This consists mainly of arthrodeses of the tarsal joints and the lengthening and transplantation of tendons about the ankle. Frequently the presence of a spina bifida is not discovered until the resistance of a foot deformity to closed methods of reduction suggests the advisability of an x-ray examination of the spine. Stabilization of the foot, with lengthening or shifting of tendons to balance more properly the forces acting on the tarsus constitutes a plan of treatment which is effective in permanently correcting a deformity which is due to a congenital muscular imbalance.

Congenital dislocation of the hip and lumbodorsal scoliosis, frequently found in association with a spina bifida occulta, present no distinctive clinical features and are treated according to rules applicable to the handling of such conditions generally. Cases of spina bifida occulta with bladder or bowel dysfunction require treatment to reinforce sphincter control. The possibilities for bringing relief to cases of this type have been mentioned previously, in connection with the problem of urinary and fecal incontinence in spina bifida cystica.

ILLUSTRATIVE CASES

A 171, male, age 12 years. Spina bifida occulta, tenth dorsal to first sacral. Examination: dislocation of left hip; pes valgus, bilateral. Treatment: closed reduction of hip dislocation; tenotomy of peroneal tendons, bilateral; double arthrodesis, left. Result: patient walking well, feet in good position.

D 130, male, age 7 years. Spina bifida occulta, all sacral vertebrae. Examination: dislocation of both hips; pes equinovarus, bilateral. Treatment: closed reduction of hip dislocations; repeated manipulations of feet; tenotomy of Achilles tendons; double arthrodesis, bilateral. Result: it was necessary to restabilize feet two years after bilateral double arthrodesis.

F 188, female, age 7 years. Spina bifida occulta, fifth lumbar and first sacral. Dislocation of both hips; pes equinovarus, left; contracture of knee, left, with tibial torsion. Treatment: lengthening of heel cord, left; open reduction of both hip dislocations; subtrochanteric osteotomy, right; arthrodesis of left hip; triple arthrodesis, left; osteotomy of tibia and fibula, left. Result: hips stable, foot in good position after one year.

J 97, female, age 7 years. Spina bifida occulta, all lumbar and sacral vertebrae. Incontinent of urine anf feces; dislocation of hip, left; flail lower extremities; contractures of knees; pes equinus, bilateral. Treatment: deformities corrected by wedging plasters; walking begun with braces and crutches. Prognosis: poor.

LAMINECTOMY IN SPINA BIFIDA OCCULTA

Cases of urinary incontinence have been improved by laminectomy, with the removal of fibrous bands from within the spinal canal; and deformities usually appearing or becoming more marked in early adult life have been benefited by the removal of growths compromising the spinal cord or cauda equina. All explorations have not been successful, however. Indeed, Brickner, Hackenbroch and Mertz have reported indifferent results in a considerable proportion of their cases. It is now generally agreed that only severe and progressive symptoms call for an exploratory laminectomy. Enuresis of childhood, without other symptoms, is not an indication for operation. Severe paralysis of the lower extremities, present since birth, constitutes a definite contraindication to operation. In patients not benefited by laminectomy, a primary defect in the spinal cord (a myelodysplasia), or an irreversible effect secondary to pressure must be assumed.

When operative intervention is decided upon, a laminectomy is carried out in the region of the defect, and sufficient bone removed to allow a thorough inspection of the spinal canal. The dura should be opened for inspection of the cauda equina, if only to be able to estimate the prognosis for improvement following the surgical procedure, as suggested by Buchstein and Love. At operation any procedure should be carried out which seems necessary for the removal of tension or pressure upon the nerves. Care must be exercised not to injure further the nerve tissue involved. The low mortality of laminectomy would seem to justify its trial in selected cases.

SUMMARY

1. Frank spina bifida cystica, having a sac-like tumor which contains meninges, nerves, or the spinal cord itself, demands an early plastic operation to repair the spinal hernia. Frequently, however, further treatment of a reconstructive nature is necessary to correct deformities and disturbances of function due to primary nerve defects unaffected by such a procedure.

2. Spina bifida occulta, a relatively common condition, may have deformities of the extremities, muscle paralyses, trophic ulcers, and disturbances of bladder and bowel control associated with it. These associated conditions present problems for the neurosurgeon, the orthopedist, and the urologist.

3. The disabilities found in association with a spina bifida occulta may be as marked as those found in cases of frank spina bifida cystica. In childhood, symptomatic treatment is all that is generally required. In adolescent or early adult life, however, disturbances of function may appear for the first time, and defects previously stationary may suddenly assume a progressive character. In cases of this type, exploratory laminectomy can be considered a justifiable procedure, since the operative removal of processes causing mechanical interference with nerve elements has given relief in many instances.

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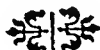
LOW BACK PAIN AND ALLIED CONDITIONS

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WHEN, in 1934, the senior author published his first paper on this subject, he introduced the term "myofascitis" for the purpose of grouping together under one clinical entity certain conditions which had been empirically diagnosed and treated under many different names, such as lumbago, sacroiliac sprain, sacroiliac relaxation, sciatica, strain of lumbar muscles, rheumatism, acute lumbosacral angle, congenital variations in the spinal column, sciatic scoliosis, contusion, low back pain, low backache, bursitis, tennis elbow, glass arm, Charley horse, ruptured muscle fibers, toxic wry neck, neuritis, crick of the shoulder or neck, and flat feet, particularly the juvenile type, and later rupture or herniation of the nucleus polposus. The introduction of the term has great advantage as it eliminates confusion arising from a multiplicity of different terms based on anatomic locations of the patient's complaints, which are merely different manifestations of the same disease. It is an anatomic and descriptive designation indicating both general location and pathology of these toxic conditions.

Myofascitis is the term used to designate toxic inflammatory or metabolic changes of muscles and their associated fasciae, and its local symptoms closely resemble those of the conditions just listed. It has successfully masqueraded under these diagnoses for years by concentrating the physician's attention on these local or secondary manifestations, usually orthopedic in nature rather than upon the underlying causes, faulty metabolism or toxicity of the blood. The term myofascitis is then a better designation, because it simplifies rather than complicates our diagnostic nomenclature by pointing to the common origin of these conditions, and permits the rationalization of their treatment along one definite basic line.

The toxic condition of the blood that underlies myofascitis is evidenced locally by low-grade inflammatory changes of the muscles and fasciae, the fascial insertions of muscle to bone becoming particularly hypersensitive. The report of 1934 was based upon 840 cases. From 1934 to 1937, our previous experience enabled us to look more carefully for this condition, and today our records show a total of 1,188 cases which have been diagnosed and treated.

ETIOLOGY AND PATHOGENESIS

Sex. Myofascitis is slightly more frequent in the male sex, 57 per cent in these series being males.

Age. Age is no barrier to myofascitis. There were patients under 3 years of age and over 80 in our records. The number of cases increases with age up to 40 years. + Twenty-five per cent of the cases occurred between 20 and 30 years of age, 29 per cent between 30 and 40 years of age, and 39 per cent between 40 and 50 years of age.

Trauma. Trauma is of secondary importance, only aggravating a preëxisting myofascitis or contributing to localize at a particular site in a group of muscles or fasciae, toxins which are being carried by the blood and lymphatic systems. Even by considering as an accident the simple lifting of a light object, we could find trauma as a factor in only 25 per cent of cases. In most of these cases, the muscular effort or lifting was not considered as having any etiologic relationship but merely called the patient's attention to the fact that his muscles were already sensitive.

Infection. The main factor causing myofascitis is focal infection. We were able

to find focal infection of various types in 52 per cent of the cases. Infected teeth were found in 20 per cent. Less frequent were infections of the tonsils and the throat (7 per cent of the cases); of the nose and sinuses (6 per cent). Colds, abscesses, osteomyelitis, gall-bladder infection, colitis, appendicitis, lithiasis, prostatitis, pyelitis, cystitis, mastoiditis, gastric ulcer, gynecologic conditions, tuberculosis and pulmonary abscesses were also found to be the responsible original foci of infection.

Constipation. Constipation is another prominent toxic source and in 151 cases (a percentage of 12 per cent) this was found to be the cause of the myofascitis. Without going into a discussion of the toxic etiologic influence of histamine, we are convinced after studying hundreds of cases in which we have had stool examinations made, that histamine in large quantities in the colonic content is an index of toxicity of the stool, whether it is the principal offending toxic agent or not. It is a very helpful guide to treatment to have stool examination made in all cases of myofascitis suspected of metabolic etiology. In 7 per cent of the cases, the histamine index was found to be four or five plus above normal.

Metabolic and Glandular Disturbances. In conjunction with those of metabolic origin, glandular disturbances are also to be considered. It has been recognized for many years that there is a relationship between sciatica, lumbago and other so-called rheumatic conditions and gout. In many cases of myofascitis, uric acid retention was found and once this condition was corrected, the symptoms disappeared. We believe this finding to be so important that determination of the blood uric acid has become part of our routine investigation to determine the etiology of a doubtful case. In the same line, nervous strain is a frequent cause of myofascitis. During the recent depression, the causation in numbers of cases has been contributed to by extreme nervous strain and apprehension, leading to metabolic disturbances. In most of these cases, the muscle effort incident to lifting

was not considered as having any etiologic relationship.

Vitamin Deficiency and Allergy. These are also factors responsible for myofascitis attacks. Among glandular disturbances, hyperthyroidism is the most important, possibly because of the metabolic disturbances integrating this syndrome.

PATHOLOGY

The pathology of myofascitis is not yet very well known, the reason being that necropsies and biopsies are not frequently available in such cases. Subcutaneous nodules have been found to contain a gelatinous substance with leucocytic infiltration. Chronic inflammation of fasciae covering the muscles or nerves has been described. Physicochemical alterations of the muscular fibers have been observed and were described under the name of myogelosis by Schade. In some cases, real histologic lesions in the form of round-cell infiltration have been detected by the author and are so marked as to be considered evidence of a true myositis.

SYMPTOMS

Manifestations of toxic involvement are usually of a low grade. The increase of the diameter of a limb is a frequent finding, but it is surprising that more cannot be found in the way of edema or exudate.

Pain. The most frequent location of pain is the lower back, where there are so many fascial insertions into the bone. We have found that this location predominated in 54 per cent of cases although other regions of the body were at the same time involved. Other regions of the body are susceptible in the following order; the lower extremities, the upper extremities, the neck, and the scalp and muscles of the face. Why this condition should so universally involve the gluteal and hamstring muscles and particularly when it is unilateral, why it should involve the left side in a ratio of 60 to 40 per cent—we have no explanation. Although in the low back cases the pain may seem to be in the

sacroiliac joint, upon more careful study, it is found to be more widely distributed in the surrounding muscular insertions, particularly the pyriformis muscle, most of the origin of which is the capsule of the sacroiliac joint.

Leg Raising Test. In practically every case of low back pain, flexion of the hip with the knee extended causes tension and resultant acute pain at the fascial insertions of the gluteal and hamstring muscles into the bony structures in the region overlying the sacroiliac joint. This same test is of inestimable value in serving as contributory evidence that pain in some remote part of the body may be due to the same cause. Therefore, every physical examination in our clinic includes the so-called myofascitis test, even when no symptoms have been complained of in the region of the gluteal or hamstring muscles. When this is supplemented by headache, it is still more confirmatory.

Weakness. This is another very important symptom, occurring subsidiary to pain or occasionally existing as the chief one.

Spasm. This is a frequently observed symptom, especially noticeable in the lower back, hamstring and calf musculature. In acute cases, muscular spasm may come on in involved muscles as an explosive manifestation. A golf player may on this particular occasion drop to the ground with the severest of pains in his back from swinging at a golf ball, an act he has done thousands of times with impunity. It is believed that on. this occasion because of the presence of myofascitis, an adhesion in his muscle gave way, setting up violent painful spasm in the surrounding muscles. The same event may result in endless litigation when a workman in line of duty has a similar thing happen from a relatively innocent lift or motion.

DIFFERENTIAL DIAGNOSIS

The differential diagnosis of myofascitis from other conditions having as their main symptom low back pain is of great impor-

tance. The necessity of a better understanding of this condition by the medical profession cannot be overestimated. It is of equal interest to the orthopedic surgeon, the neurologist, the general practitioner or the internist, the gynecologist or even to the cardiologist. Cases of myofascitis can be mistaken for many other conditions. We have in our records, cases which have been operated on for appendicitis, cholecystitis and retroversion of the uterus, which were afterwards found to be simple instances of myofascitis relieved by adequate treatment based on the right diagnosis.

Rarely does one encounter a condition in which greater diversity of opinion exists among eminent physicians as regards its diagnoses and treatment. So a careful differential diagnosis is our main preoccupation in labeling a case of myofascitis. X-rays are always taken and only when they are negative is the case considered pure myofascitis. Myofascitis is undoubtedly a pre-arthritic condition and our records show that 7 per cent of the old cases of myofascitis are complicated by arthritis of the spine. A number of cases have been observed where there were no evidences of joint involvement and the diagnosis of myofascitis was made. Several of these patients who failed to undergo treatment came back at a later date with a real arthritic condition. In other words, neglected myofascitis may lead to arthritis. Symptoms of the former are danger signals that the latter is impending. Constant absorption of poisons into the circulation may result in arthritis, arteriosclerosis or some other lesion even more serious than myofascitis.

Myofascitis is prevalent in muscular individuals of a plethoric nature who have formerly been athletes, but who, at the time of onset of symptoms, are leading sedentary lives. The cause may be, to a degree, occupational, too sedentary a life leading to uric acid retention and toxic absorption.

It is incredible the great number of sacroiliac fusion operations that have been

performed for simple cases of myofascitis. In later years, fusion of the lumbosacral joint has also become very popular. As could be expected, the symptoms are frequently not relieved by such operations. Recently many other operations have been devised for the relief of low back pain, such as the Ober operation, consisting of severing the iliotibial band transversely between the crest of the ilium and the greater trochanter. Excision of the pyriformis muscle was the last one proposed (by the way—an old idea, presented by Barshinger in 1908, but not tried by its inventor on the living subject). The operation recommended by Percy Roberts raised a question. Percy Roberts was performing a sacroiliac fusion for low back pain, but the patient went back on the operating table and he was forced to stop the procedure with only the approach finished. Unexpectedly the patient made a complete recovery. The query arises therefore, in those cases relieved by fusion of the sacroiliac joint: was the relief due to the fusion per se, or was it due to the stripping of the insertion muscles from the overlying bony structures?

We have in our clinics every day patients on whom such operations have been performed without any result, or have been recommended by one or more consultants. We have seen 283 cases where an operation was recommended, fifty-two in which one or more fusion operations were performed, with no relief of symptoms. All of these patients improved immediately or were ultimately cured when the right diagnosis was made and the adequate treatment carried out.

The following is the history of an illustrative case recently observed in our Clinic:

CASE 1. This patient stated that he was injured on October 21, 1933 while lifting a weight, when he experienced sudden sharp pain at the lower end of his spine, radiating to the right hip and leg. This pain was definitely situated over the right buttocks and shot down to the outer side of the thigh and lower leg, even to the outside of the ankle and foot. In other words, a typical manifestation of myofascitis.

The pain continued and the patient was sent to a well-known orthopedic surgeon in Boston who recommended a spinal fusion. At that time, no study of possible foci of infection was made. The patient was admitted to the hospital for operation May 10, 1934, but was suddenly taken with an attack of acute sinusitis and the attempt to fuse the spine was delayed for one month. In June, 1934, this operation was done and it apparently was a regular Hibbs fusion, with periosteal graft from the left tibia. The patient was later treated for sinusitis. He felt temporary relief following the operation, but the pain recurred. One year later, the same orthopedic surgeon performed a sacroiliac fusion with no ensuing relief. Since that time, the patient has been subject to recurring attacks of pain and disability with intervals of relief.

At the time of our examination of this patient on March 17, 1938, he stated that during the previous two years, two teeth had been extracted. He further stated that in spite of the two operations, the pain in his back and lower right extremity was much worse than ever.

The examination on March 17, 1938, revealed many badly abscessed teeth, limitation of motion of the spine (and the patient also complained of grinding at about the center of the supposed fused area) with scars of operations on lumbosacral spine and left sacroiliac joint. The myofascitis sign was positive, bilaterally, being very marked on the right side. Reflexes were normal. A grinding sensation was present at times. X-rays revealed failure of fusion between the fourth and fifth lumbar vertebrae. There was a fusion of the right sacroiliac joint.

The lesson to be drawn is that this patient presented a typical case of myofascitis with the focus of toxic infection markedly present at the time of both operations and still the prominent orthopedist who operated did not consider the abscessed teeth nor the sinusitis of any etiologic relation to the low back pain. The whole criteria in the treatment of the case had been operative fusion of numerous joints in the region of the pain although no x-ray pathology was manifest. The untreated myofascitis with its symptoms still existed

when we last examined this patient. It is surprising that the failure of comprehension and the illogical treatment are still seen today in a considerable portion of orthopedic practice.

Myofascitis and Neuritis. Acute pyogenic infection of a nerve practically does not exist. A nerve can remain free of any infection even in contact with a pocket of pus, and metastatic localizations in a nerve from a distant source of infection are unknown. One must be very careful in making a diagnosis of neuritis of an individual nerve, and not rely upon tenderness on pressure over a certain point or too much pain involving the distribution of a nerve. Myofascitis may result in identical spots of tenderness and identical underlying causes.

Myofascitis and Cord or Nerve Root Compression by Lesions of the Nucleus Pulposus. The nucleus pulposus of Schmorl has been recently resurrected to play an outstanding rôle in the pathology of sciatica and low back pain. The experience of the senior author allows him to state that quite a percentage of cases of so-called "nucleus pulposus compression" constitute cases of myofascitis, and while not denying that this entity exists, he feels certain that it is extremely rare.

Myofascitis and Female Pelvic Organs. We have, in our records, eighteen cases in which different operations were performed—suspension of the uterus, salpingectomy, total hysterectomy, etc.—and two cases in which operation was refused, all relieved when treated for more or less severe myofascitis.

Myofascitis and Malignancies. Myofascitis sometimes complicates malignancies, particularly bony malignancies. Every time we have to deal with a somewhat atypical case of myofascitis, especially one not responding promptly to the proper treatment, we become suspicious of something more serious—occasionally a malignancy.

Myofascitis and Neurosis. Neurotic patients or compensation cases with simulated lower back pain are of daily observation in every clinic. The myofascitis test (the leg raising test) and other special features of neurotic conditions make the diagnosis clear to an advised expert.

Myofascitis and Flat Feet. Myofascitis is a complication very often observed with flat feet, especially of the juvenile type, and may considerably aggravate this condition by increasing the rigidity of the feet. The long continued spasm and contracture of the calf muscles which exist in chronic myofascitis increase the plantar rotation of the os calcis. We have seen many of these cases in which operative lengthening of the tendo Achillis has been done due to a lack of understanding of the true etiology of the temporary muscle shortening.

Myofascitis and Affections of the Cardiovascular System. The following reference to one of our cases, already published in a previous paper will serve as an illustration. This patient, an author, who had led a sedentary life, came in complaining of low-back pain. He had also been troubled for many years with a diagnosed serious heart condition and was still being treated by an eminent heart specialist. Inasmuch as the myofascitis test was positive, it was suspected that we were dealing with a case of toxicity, probably with an apical abscess as the source of infection. A badly diseased tooth, with a large sac of pus was extracted. After the elimination of this toxic source and treatment of the patient's colon, not only did the low back pain disappear, but the symptoms of heart disease as well.

TREATMENT

Since toxic absorption or metabolic disturbance is the underlying factor, treatment is primarily aimed at their elimination and secondarily at the local orthopedic manifestations. In cases seen early, mechanical immobilization treatment is entirely avoided, except for a short period in the most acute cases. Local treatment, when applied, may consist, in the most acute cases, to temporary recumbency in

bed and, in less acute cases, to plaster of Paris splintage or adhesive strapping.

Of the many possible foci of origin of toxicity, teeth stand at the head of the list in frequency. In the majority of the cases which we have seen, the oral cavity has been the offending source. It has further been observed that in case of long standing oral infection, whether the primary source be in the tonsils, teeth, antra or other sinus, there is likely to be a residual toxicity in the colon. In 12 per cent of the cases, the colon was found to be the only offending source. When the primary oral focus is eliminated, it has become a common practice to carry on a supplementary elimination treatment of the colon.

Colonic Lavage. As soon as an analysis for toxicity of the feces has been found positive, the colon is treated daily with medicated lavage. There is no need for extensive apparatus for this. A great deal of undesirable practice has grown up, furthered by ambitious manufacturers, to use an apparatus of a more or less complicated nature to impress the patient. However, this actually accomplishes little so far as lavage of any appreciable portion of the colon is concerned. It is claimed that the average colon has about 500 square inches of surface. Some of this apparatus, particularly of the two-way type, brings the fluid into a particular spot of the colon and discharges it through another tube at practically the same point, thus reaching only a few square inches of the colon. The patient is particularly impressed by seeing or hearing this stream of water flowing for a considerable period of time through the tube and out of the colon, and he believes that the whole interior is being thoroughly washed. The actual lavage is much more thorough when carried out by a short glass anal tip and ordinary fountain syringe, the volume of the fluid, posture and specific gravity being trusted to assure the fluid reaching the upper portions of the colon.

Technique. The patient is placed upon the left side with the buttock elevated on two pillows. This posture is important. A reservoir holding two quarts is elevated not more than 18 inches above the inflow, in order that peristalsis may not be unduly stimulated and an involuntary effort of expulsion of the fluid induced, thus interfering with the treatment. A short glass rectal tip is used. A low enema of a pint of lukewarm water is given to clear out the feces from the extreme lower portion of the colon. After this has been fully expelled, a second lavage consisting of one teaspoon of calcium in 2 quarts of warm water is allowed to flow slowly in; this will usually take about ten minutes. With the buttock still elevated, the patient then lies upon his back, with the thighs extended for a period of two or three minutes, then on the right side with the buttock still elevated for an additional two or three minutes, to permit the solution to flow as much as possible into the ascending colon and cecum. He is then allowed to go to the toilet and expel all of this fluid (a bed pan may be used if the patient is a bed case). This expulsion will be hastened by walking a little and will consume from ten to fifteen minutes.

The patient then takes the same position on the treatment table as before, and one teaspoon of sodium carbonate monohydrated, dissolved in 2 quarts of lukewarm water, is allowed to flow into the colon in precisely the same manner as the calcium lactate solution, but is retained a few minutes longer than the previous lavage. The treatment should be continued daily until the last fluid comes away without much mucus.

The administration of this lavage must be handled by some one having experience. Although it is a simple procedure, it is not entirely harmless or free from accident. There have been cases registered of rupture of the colon during a colonic irrigation, and we have in our files a case of severe hemorrhage after the administration of such a treatment.

Introduction of Bacillus Acidophilus by Mouth, or by Colonic Implantations. Much

has been accomplished by sweeping out of the colon abnormal mucus, acid and toxic products, and bacteria; but one should not rest with this lavage as it is very likely to have temporary benefits, and the same harmful products may slowly accumulate again. Inasmuch as the bacterial flora have such a marked influence upon the proper function of the colon, every effort should be made to influence the development of the proper flora. The bacterial agent which I have used to accomplish this is the Bacillus acidophilus. Its growth in the intestinal tract in large numbers may be stimulated in several ways.

It has been revealed by careful study that when a patient is given lactose for a considerable period of time, the Bacillus acidophilus will slowly increase in the colon. In other words, lactose is a favorable medium for these bacilli to grow upon. Consequently, when it is found that faulty metabolism is due to a deficiency of Bacillus acidophilus in the colonic flora, the substitution of lactose (two tablespoons or more per twenty-four hours) for table sugar should be carried out. This is not unpleasant to the patient, as it can be used for sweetening coffee, cereal, etc., but inasmuch as some people eat but little sugar, it should be emphasized to them that the quantity prescribed must be taken as faithfully as medicine. For treatment purposes, this method alone is entirely too slow. It is, therefore, wise to give by mouth, two teaspoons of a culture containing not less than 200,000,000 active bacilli per c.c. before each meal. If the patient prefers, various milk preparations or acidophilus-charged beverages may be used. Also, the bacilli may be implanted after the last lavage in a small quantity of water and lactose, with a catheter.

Heliotherapy. Heliotherapy is most beneficial in the majority of these cases.

Diet. A low residue diet is prescribed which prevents carbohydrates from reaching the colon in undigested form. As Finker and von Wasserman have proved that autointoxication is the result of bacterial activity on certain sugars, elimination of the offending sugars from the diet and the substitution of lactose for ordinary table sugar may account for the beneficial results.

To forestall any possibility of residue protein reaching the colon undigested, or bringing with it partially digested carbohydrates and liberating them in the colon, proteins and meats are taken in only moderate quantities and the importance of thorough mastication is impressed upon the patient. The work of Kellogg at the Battle Creek Sanitarium has taught us much regarding the relation of diet to the action of the colon, and the influence of the colon upon health.

To help restore the alkaline balance, citrus juices, particularly tree-ripened grapefruit juice* or alkaline waters are given frequently. Fifteen grains of calcined magnesia and calcium lactate are often given in water after eating, three times daily. This régime tends to overcome, without harmful cathartics, the constipation which is so frequently present in cases of myofascitis.

Local Mechanical Treatment. Local mechanical treatment in the form of belts, corsets, braces, plasters, etc., is applied when indicated, but the treatment outlined alleviates local symptoms to such an extent that the need for mechanical treatment is surprisingly diminished, and is entirely secondary and always temporary.

Deep massage to the parts complained of is the most important part of the treatment. It is believed that the toxicity is present in both muscle and fascia, particularly in the lymphatics. Repeated stretching by the physiotherapist of the lumbosacral region by forcibly flexing the hips with the knees extended, without anesthesia, as carried out for cases of so-called sacroiliac strain, often helps to

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* Inasmuch as fresh grapefruit is usually shipped in the semigreen state, the most trustworthy way to get tree-ripened grapefruit juice is to buy that specially canned from ripe fruit.

give relief in chronic cases of this kind, the result being that muscular and fascial adhesions are ruptured and overcome. This explanation is offered as accounting for instances of relief brought about by physical causes by osteopaths and chiropractors through manipulation on various parts of the body.

PROPHYLAXIS

Undoubtedly outdoor exercise aids in maintaining normal metabolism and patients who are on the threshold of myofascitis avoid recurrence by following a favorable daily régime. In particularly stubborn cases the patient should be urged, if possible, to live in a warm, sunny climate.

SUMMARY

Myofascitis is a common condition due to a low-grade inflammation of the muscles and fasciae. Focal infection is the basic cause with trauma frequently acting as the exciting or aggravating factor. The differential diagnosis is difficult as myofascitis simulates or complicates a wide variety of conditions.

Treatment consists of improving the hygiene of the patient and elimination of toxicity by a combination of methods; removal of the source of cause of toxicity, local massage, colonic lavage, stimulating the growth of bacilli acidophilus in the intestinal tract and attention to diet. Local mechanical treatment is also applied when necessary.

INJURIES INVOLVING THE PELVIS*

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THE anatomic restoration of fractured fragments usually results in a normal function of the part. Although this place seemed unfortunate but could not be helped. In those individuals who could not become pregnant this mattered little,
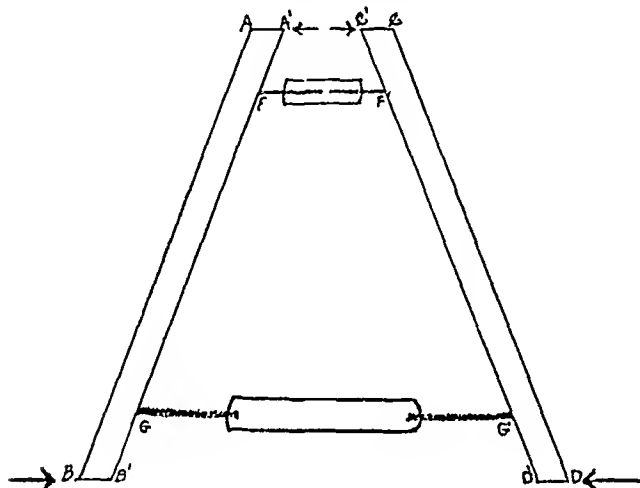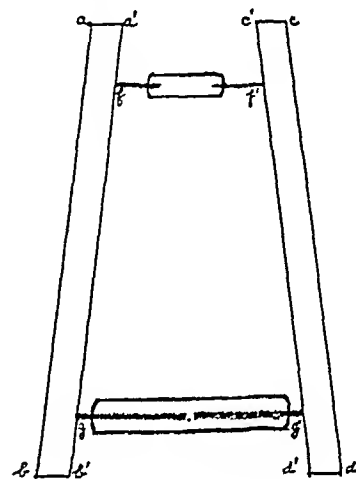
FIG. 1.   FIG. 2.

FIG. 1. Before reduction. Parallelograms AA'B'B and C'CDD' represent the two plaster of Paris dressings on the lower extremities. A and C cover the greater trochanters. A' and C' are just below the inguinal fold on its medial aspect. F and F' represent the position of the double receptors, fixed to which are the two small and closed turnbuckles, situated about 4 inches below A' and C'. G and G' represent the position of the single receptors to which the large and open turnbuckle is fixed. Its anatomic position is just proximal to the medial malleoli. For simplicity only one turnbuckle is used in all the illustrations. The arrows indicate the points of greatest force.

FIG. 2. After reduction. The small letters correspond to the capital letters in Figure 1. The proximal turnbuckles between f and f' have been opened. Note the greater distance between these two points as compared to the distance between F and F' in Figure 1. The large and open distal turnbuckle has now been closed. The points of greatest pressure are at a' and c' where the greatest work is being done and also at b and d where the greatest effort is taking place. As a result of these actions the distance between a' and c' is much greater than that between A' and C'. Since the objective is to produce traction in a horizontal plane, this must needs be the case.

does not hold true in all cases, it is to all intents and purposes the aim of those practicing traumatic surgery to obtain this anatomic restoration.

Particularly is this true of fractures through the pubes, when overriding is present. The treatment in the past has been one of rest in a canvas hammock, with or without traction on the extremities. It is undoubtedly true that these fractures healed even in malposition. The narrowing of the pelvic outlet and inlet which took

but in those who expected to bear children this unfortunate sequela was of major importance. In these individuals normal delivery was out of the question and cesarean section was the only method of choice.

The author's method† of treatment of these injuries is predicated on the principle of traction. Since the overriding in this type of injury takes place in a horizontal plane

† JAHSS, S. A. Injuries involving the ilium. *J. Bone & Joint Surg.*, 17: 338–346 (April) 1935.

* From the Hospital for Joint Diseases, New York City.

it necessarily follows that traction must also be in that plane. To obtain this result it is necessary to use both lower extremities

shaped, it is necessary to bevel the edges of the hole in the felt to conform with this anatomic configuration. When the pad is
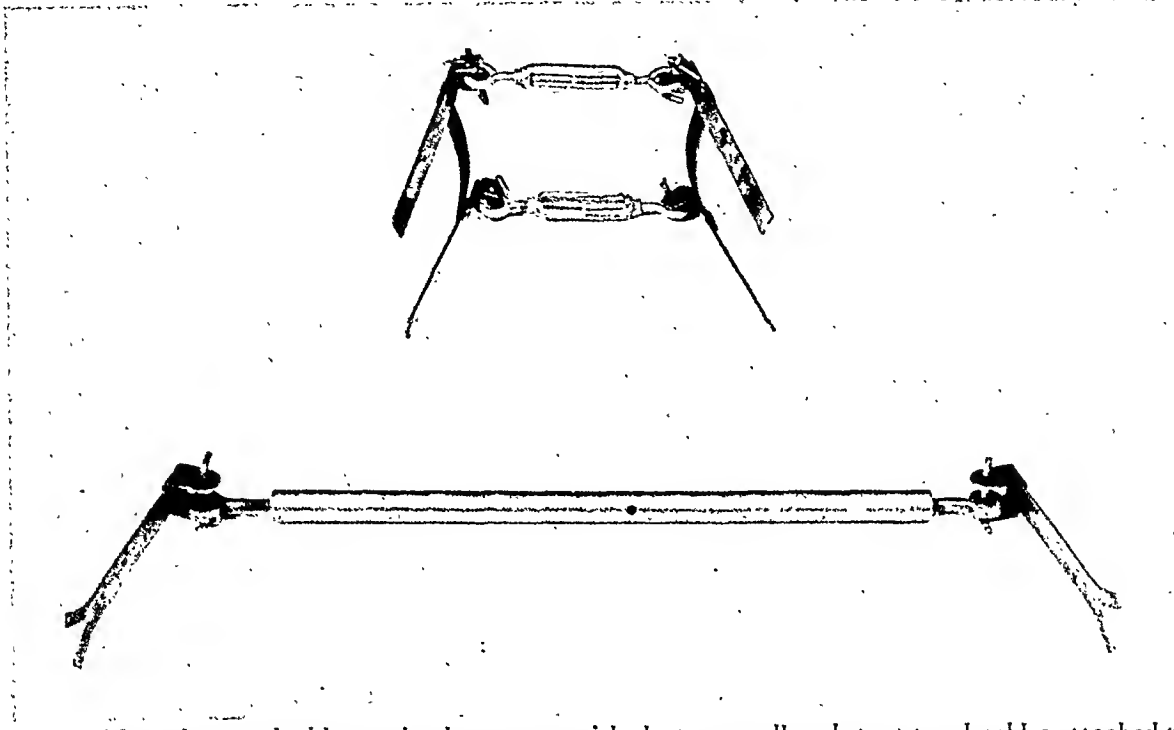
FIG. 3. Note the two double proximal receptors with the two small and stout turnbuckles attached to them. Note that the large turnbuckle is fixed to the two single receptors. The tubular type of turnbuckle is now used when a large one is indicated. It is much lighter, less bulky and is just as efficacious. The turnbuckle is modified in length by turning the tubular portion. This is done by introducing a heavy nail through a hole in the center of the tube and turning it either clockwise or counterclockwise. The length of the small and closed turnbuckle, from end to end, measures 6½ inches. The large one, fully closed, measures 21 inches. Note the curved transverse metal piece connecting the arms of the double proximal receptor. This is curved to conform with the shape of the thigh. Note the parallelism of the proximal turnbuckles and when fixed in position they are in the same anteroposterior plane. These turnbuckles are exactly 4 inches apart.

as levers which, through the medium of the ligaments of the hip joints, pull on the two ilia and "distract" the fragments. (Figs. 1 and 2.)

The technique consists of three steps:

1. *Padding.* The following procedure is carried out on both lower extremeties. The limb, from toes to groin, is padded with one layer of tailor's thin white felt. A piece of heavy felt, 8 inches long, 4 inches wide and at least ¾ inch thick, is placed at the medial and most proximal part of the thigh, the longer dimension being placed horizontally. Another piece of this heavy felt, 4 inches square, is used to protect the external malleolus, where the plaster will exert much pressure. In this piece of felt a hole is cut, large enough to admit the malleolus. Since the malleolus is cone-

placed over the external malleolus it will be seen that the upper surface of the pad extends beyond the upper surface of the malleolus. In this way no direct pressure can be brought to bear on the malleolus proper. These two pieces of heavy felt are held in position by a second layer of thin white felt. The principle of heavy padding can be best summed up, viz., *protect those parts where there will be a maximum of pressure or force.*

2. *Plaster of Paris Bandaging.* The lower extremity, with the knee in full extension and the foot at 95 degrees to the leg, is then bandaged with two layers of plaster of Paris, the proximal end being just distal to the proximal edge of the heavy felt pad, while the distal end is just distal to the metatarsophalangeal joints.

The *single* receptor for the distal turn-buckle is now placed just proximal to the medial malleolus. A heavy plaster of Paris

tor. Another and heavier reinforcement, ³₄ inch thick, 8 inches wide and about 10 inches long is placed at the proximal

FIG. 4. After reduction. Note the open proximal turn-buckle which was closed previous to reduction and the closed distal turnbuckle which was open before reduction was begun. Note the squaring of the perineal area which, of course, is due to the pushing apart of the upper ends of the thighs. Note also the external rotation of the extremities. This is due to the fact that only one turnbuckle was used proximally instead of two. (From Jahss in *J. Bone & Joint Surg.*, 17: 338, 1935.)

FIG. 5. Fracture through the ascending and descending rami of the pubes. Before reduction. Note the marked narrowing of the obturator foramen, due to the overriding of the fragments. Note also the disturbed dimensions of the pelvic inlet. (From Jahss in *J. Bone & Joint Surg.*, 17: 338, 1935.)

reinforcement, ½ inch thick, is placed over the arm of the single receptor. (Fig. 3.) This reinforcement should be long enough and wide enough to extend 2 inches beyond the edges of the arm of the recep-

and medial end of the plaster. The 8 inch dimension is placed directly over the piece of heavy felt and the 10 inch dimension assumes a longitudinal position. Four inches from its proximal edge the *double*

receptor is placed on the plaster reinforcement. This *double* receptor is used so that *two* turnbuckles can be used proximally.

Note that at the *ankle* the single *receptor lies under* the *plaster* of *Paris reinforcement,* whereas at the *groin* the double

Fig. 6. After reduction. The obturator foramen is normal in outline. Note the reëstablishment of outline in the pelvic inlet. Compare with Figure 5. (From Jahss in *J. Bone & Joint Surg.,* 17: 338, 1935.)
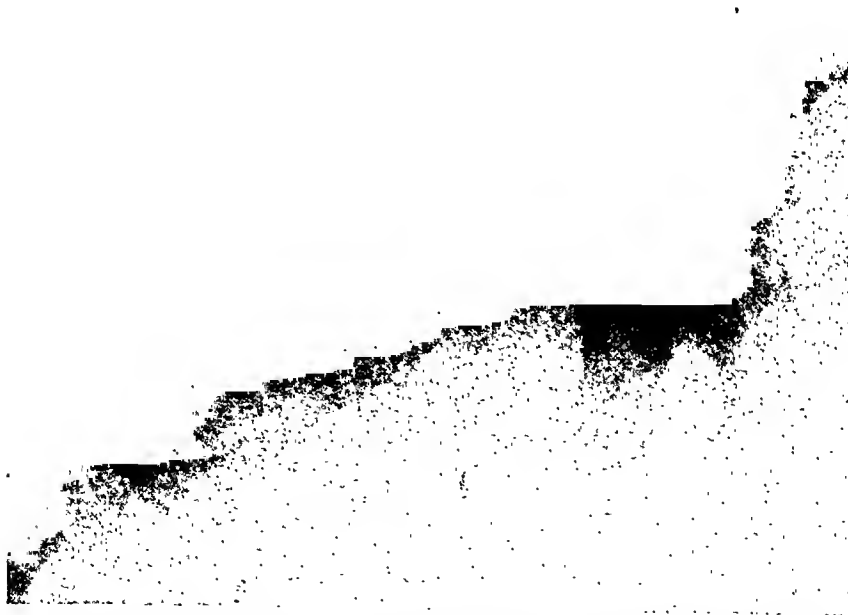
Fig. 7. Fracture through the pubes. Marked narrowing of the obturator foramen. Overriding, without much visible evidence of a disturbance in the dimensions of the pelvic inlet.

(Fig. 3.) Four or five layers of plaster of Paris are now added to the entire dressing, from toes to groin, to hold the receptors and the reinforcements, and to add strength to the entire dressing.

receptor lies on the *reinforcement.* The reason for this is quite obvious. Since the ankles will be pulled toward each other, that portion of the plaster over the single receptor must be reinforced in order to

withstand the strain. In the groin the thighs will be pushed apart and therefore it is necessary to reinforce that portion

are now moderately abducted and the *large* and *open* turnbuckle is fixed to the distal single receptors. The *proximal turnbuckles*

FIG. 8. After reduction. The obturator foramen is normal in outline.

of the plaster which is under the double receptor. The principle of the *placing* of the *receptor* can be simplified by saying that it should be *placed* where the *direction* of *force begins* and the *plaster reinforcement* should be *placed* where the *direction* of *force continues*. Since the greatest amount of work or force will take place at the medial and proximal edge of the plaster, it is necessary to have this part heavily reenforced. (Fig. 2.)

3. *Reduction of the Fracture.* The *plasters must be thoroughly dry* before reduction is attempted. This usually requires about twenty-four hours. When such is the case the turnbuckles may then be placed in position. Before putting the *two closed* turnbuckles in the double proximal receptors, two assistants pull the upper ends of the thighs apart as much as possible. This allows for the reception of the two small, stout and closed turnbuckles, which are held in position by cotter pins. Should the surgeon fail to take the precaution to pull the thighs apart he will find that only very small turnbuckles can be used. These are usually very frail and will never be strong enough to act as fulcra. The arms of these frail turnbuckles will bend and their purpose will be defeated. The limbs

are now slowly opened to their fullest extent. These turnbuckles are 4 inches apart, one being anterior and the other posterior, but both are medial and in the same plane. (Fig. 3.) When only one turnbuckle is used proximally it produces external rotation of both lower extremities and therefore a good measure of the distracting force is lost. (Fig. 4.) By using two turnbuckles this tendency is overcome. A few turns are now taken to close the distal turnbuckle. A few more turns are taken about two hours later. This procedure is followed every two hours until the over-riding of the fragments has been reduced. If the surgeon so desires, he may reduce the fracture at one time instead of piecemeal. Usually it is necessary to close the distal turnbuckle almost completely before satisfactory reduction is accomplished. The best guide, of course, is the roentgenogram.

When the proximal turnbuckles are opened they push the upper ends of the thighs apart. Now when the distal turnbuckle is closed the proximal turnbuckles act *only* as *fulcra*. As the *effort* is being applied by the distal turnbuckle the *work* or force is being exerted on the proximal and medial edges of the plasters. These edges are pushing the upper ends of the

thighs apart. This force naturally is in a horizontal plane which is the plane of the overriding. *Traction* through *distraction* is produced. (Fig. 4.)

some degree of pain is usually present during the reduction and lasts until the head of the femur is disengaged from inside the pelvis. As soon as this occurs the relief is

FIG. 9. Before reduction. Comminuted fracture of the acetabulum, with the head of the femur driven into the pelvis. Note the relationship of the head of the femur to the obturator foramen. Half of the neck of the femur is lying in the acetabular cavity. The lesser trochanter is very close to the tuber ischium.

FIG. 10. After reduction. The head of the femur is out of the pelvis and is now in normal relation to the obturator foramen. The neck of the femur is out of the acetabular cavity and the lesser trochanter is far from the tuber ischium. Even the displacement of the large fragment lying loose in the pelvis has been substantially reduced.

Immediate relief from pain is the usual rule soon after treatment is instituted. The patient is able to assume the sitting position, can be handled very easily, and is able to feed herself. Hygiene is uncomplicated; no anesthesia is required, and most important of all, only four or five days of hospitalization are required.

The plasters should not be removed until bony union has taken place. This usually requires about six weeks. (Figs. 5, 6, 7 and 8.)

CENTRAL FRACTURE OF THE ACETABULUM OR INTRAPELVIC PROTRUSION OF THE HEAD OF THE FEMUR

The same method of treatment is applicable to this type of injury. In these cases

sudden and permanent. One of the patients (Figs. 11 and 12) stated that he felt a sharp click and from then on he experienced no more pain. Weight bearing should not be permitted until firm bony union has taken place. The plasters, though, may be removed after five or six weeks. When reduction has been accomplished, the patient may be sent home. (Figs. 9, 10, 11 and 12.)

SEPARATION OF THE SYMPHYSIS PUBIS

In this condition a force, *opposite* to that already discussed, is essential. Since in this type of injury the pelvic inlet and outlet become widened, it is necessary to narrow these dimensions, and therefore a compressing force is indicated. Previous treat-

ment was carried out by placing the patient on a canvas sling and crossing the ends anteriorly over the ilia. Weights were

less of an indirect way of obtaining a closure of a separation of the symphysis pubis. With the author's method the com-

FIG. 11. Before reduction. Comminuted fracture of the ilium, acetabulum, and pubes, with the head of the femur driven into the pelvis. The hip joint space has been obliterated. Note the disturbed relationship of the femoral head to the obturator foramen, the lesser trochanter to the ischium and the femoral neck to the acetabular cavity.

FIG. 12. After reduction. Compare with Figure 11.

attached to these ends and in that way a compressing force was obtained. This treatment necessitated the supine position for a number of weeks. With this method the pressure was exerted on the crests of the ilia. Since the crests of the ilia are much more proximal than the pubic bones, the canvas sling method is more or

pressing force takes place through the heads of the femora, which are practically on a straight line with the symphysis pubis.

The technique also consists of three steps:

1. *Padding.* One layer of tailor's white thin felt is applied, from the toes to the groin. Since the greatest force will be ex-
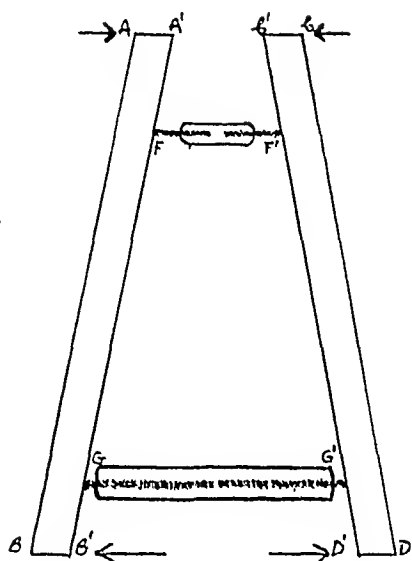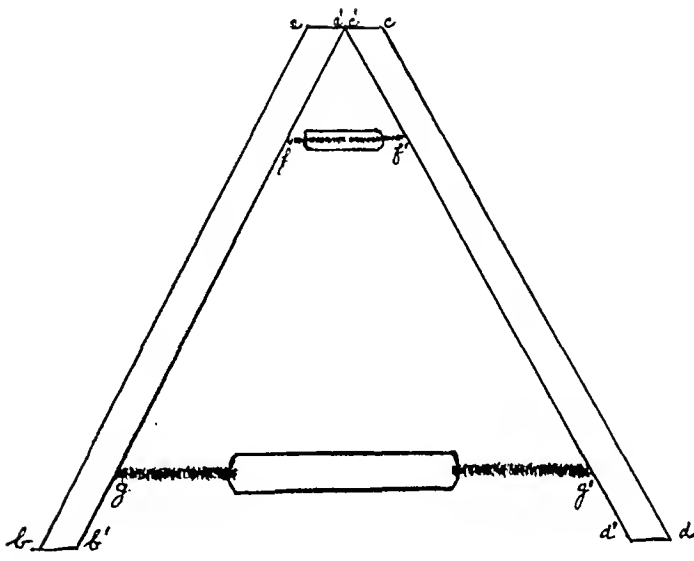
FIG. 13.   FIG. 14.

FIG. 13. Lettering is the same as Figures 1 and 2. Before reduction. Note that here the slightly open turnbuckles are placed proximally and the large and closed turnbuckle is placed distally. The proximal ones are 5 inches from the groin. Compare with Figure 1. Arrows indicate points of greatest force.

FIG. 14. After reduction. Note the marked narrowing of the perineal area, between a' and c', due to the work done on a and c, which represent the greater trochanters. The distance between f and f' is less than that between F and F'. This is due to the fact that the proximal turnbuckles have been closed.
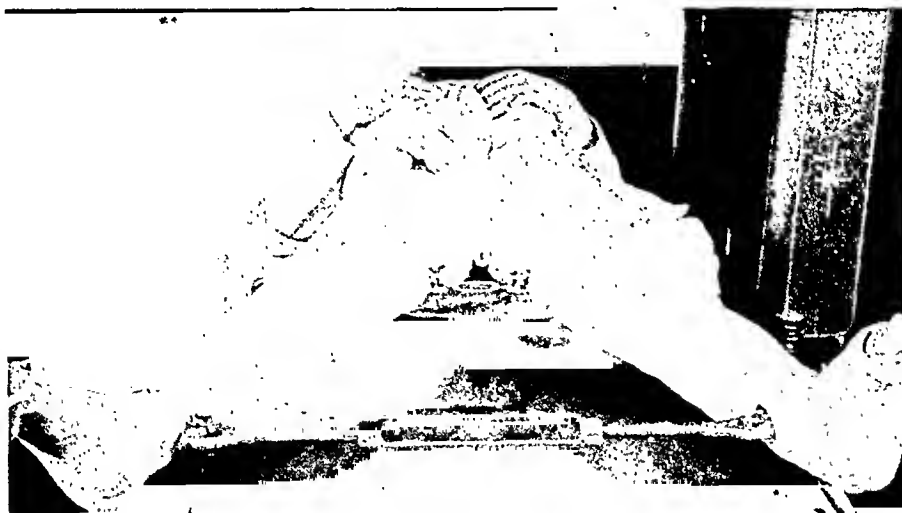
FIG. 15. After reduction. Note that the proximal turnbuckle, which was slightly open before reduction, is now closed and the large distal turnbuckle is now open, whereas before reduction it was completely closed. Note the marked narrowing of the perineal area. Compare with Figure 4. Note also the external rotation of the extremities, due to the fact that only one turnbuckle was used proximally instead of two.

erted on the greater trochanter and medial malleolus it is necessary to place heavy felt pads over these parts. (Figs. 13 and 14.)

which is covering the greater trochanter. It need be only slightly larger than the pad itself. A second and thinner plaster

FIG. 16. Before reduction. Note the wide separation of the symphysis pubis. The dimensions of the pelvic inlet and outlet are increased.

FIG. 17. After reduction. Complete reduction of the separation of the symphysis pubis. Compare with Figure 16.

These heavy pads are the same size and shape as those used for fracture of the pubes, and are also held in position by another layer of thin white felt.

2. *Plaster of Paris Bandaging.* The technique is the same as in fracture of the pubes, with these exceptions: A plaster reinforcement ⅜ inch thick is placed over the *lateral* and proximal heavy felt pad,

reinforcement, ½ inch thick, is placed distally and medially, beginning just proximal to the medial malleolus and extending toward the knee. It should be longer and wider than the single receptor *under* which it lies. Since the distal ends of the limbs will be forcibly pushed apart (abduction), the continuation of the force will be under the receptor and therefore the plaster rein-

forcement must be placed there. The proximal double receptor is placed 5 inches below the proximal edge of the plaster. This position is an inch lower than that of the receptor in treatment of fracture of the pubes. Should the double receptor be placed only 4 inches below the proximal edge of the plaster it will be seen that the space between the receptors will be too small to allow for the introduction of the turnbuckles. A thin plaster reinforcement, 1/4 inch thick, is placed over the two arms of the double receptor.

When the plasters are thoroughly dry the limbs are *slightly* abducted and two small, stout, open turnbuckles are fastened in position. These are immediately closed. At times, particularly in obese individuals, the space between the receptors is not large enough to accomodate open turnbuckles. Should such be the case it is only necessary to close the turnbuckles before introducing them between the receptors. A *large* and *closed* turnbuckle is then fixed between the distal receptors.

3. *Reduction.* The large turnbuckle may be either opened at one time or a few turns may be taken every two hours to reduce the separation of the symphysis pubis. (Fig. 15.)

The plasters should not be removed for at least six weeks. (Figs. 16 and 17.) Following the removal of the plasters a polo belt may be prescribed, if necessary.

Even in old cases this treatment will prove an ideal method, both for reduction and for immobilization following operation.

SUMMARY AND CONCLUSIONS

With the method outlined above it is possible to obtain anatomic restoration of fractures of the pubes and concomitant restoration of the normal dimensions of the inlet and outlet.

Central fractures of the acetabulum are also amenable to this treatment.

With a change in the direction of the forces, separation of the symphsis pubis can be successfully treated.

Each lower extremity, after proper padding, is immobilized in plaster of Paris in which two receptors are incorporated— a *single* one *distally* and a *double* one *proximally*.

For pubic and central fractures a distracting force at the hips is necessary.

This is accomplished by placing two small, closed turnbuckles proximally and one large and open turnbuckle distally. These are opened and closed respectively.

For separation of the symphysis pubis a compressing force is necessary at the hips.

This is accomplished by placing two small, stout and slightly open turnbuckles proximally and one large and closed turnbuckle distally. These are closed and opened respectively.

The results obtained with this treatment have been very satisfactory.

THE SHELF OPERATION FOR CONGENITAL DISLOCATION OF THE HIP*

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STABILIZATION of the hip, combined with strength and motion, demands an adequate roof of bone over the femoral head to accept the weight-bearing thrust and make possible a fulcrum-like action when the gluteus medius muscle contracts, thus preventing the sag of the pelvis which is recognized as the positive Trendelenburg sign.

In 1891 König reported the construction of a shelf of bone by turning down the outer cortex of the ilium in the treatment of congenital dislocation of the hip.

Many types of shelf operations have been recommended for patients whose hips had not been successfully reduced to the primary acetabulum. Shelves have been constructed of bone from the ilium (Dickson, Lance, Gill, Hey Groves, Lowman, Ghormley, Haas, and Crego); femur (Soutter); and the tibia (Albee, Spitzy, Roeren, Juvara, Compere and Phemister). Albee, Spitzy, Roeren, Juvara, and Gill recommended that the shelf be placed at the superior acetabular rim to make the socket of the reduced hip more adequate.

Other procedures for enhancing the stability of the hip have included the use of ivory pegs (Hey Groves) or of a boiled bone graft driven into a gouge defect above the acetabulum (Hallopeau).

The principle of cutting a new socket in the ilium or of reaming out and deepening the primary acetabulum has been employed, but Haworth and Smith reported the end results of eighty-two open operations and concluded that "the shelf operation results in less stiffening than does gouging a new socket out of bone."

Most of the shelving operations which we have performed or have observed, in which the hip was not first reduced to the primary acetabulum, have failed to accomplish the purposes for which they were intended. These patients still have a positive Trendelenburg, limp, and complain of pain in the hip.

Indications for the shelf operation are:

1. After open reduction, if the acetabulum is shallow.

2. After closed reduction, when with usage the acetabulum proves to be inadequate.

3. For the painful hip of the older child or adult, which results from a congenitally inadequate acetabulum.

The conditions which may prevail to make the shelf operation inadvisable may include the following contraindications:

1. The infant or young child before attempting closed reduction.

2. Poor surgical risk.*

3. *Failure to reduce the hip to the primary acetabulum.**

4. Extensive deformity or degenerative changes in the head of the femur.*

5. Bilateral dislocation of the hips of an older patient, because reduction of both hips without extensive trauma would be improbable.*

Choice of the source of the bone for construction of the shelf may be influenced by several factors. The shelf constructed

* NOTE: Other surgical procedures which may be recommended for these patients include: intertrochanteric bifurcation operation; subtrochanteric osteotomy; or, if degenerative changes are marked and unilateral, arthrodesis, after traction to correct the shortening from upward displacement.

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with iliac bone offers the advantage of confining the surgical procedure to the field of primary operation. The outer surface of the

mittent arthritis-like pain in both hips. The pain in the hips, present only upon walking, had recently become more marked. This
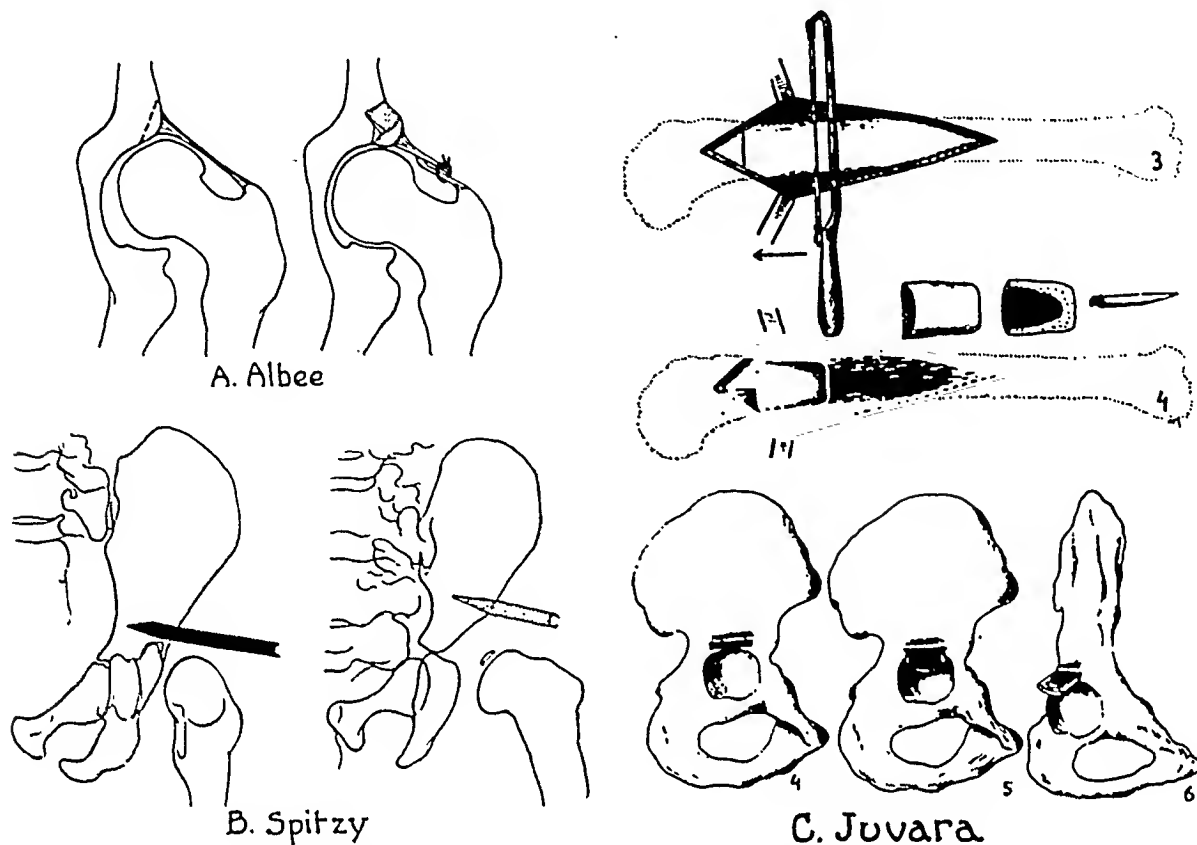
Fig. 1. Diagrammatic representation of shelving operations in which tibial bone is used, illustrating the techniques of Albee, Spitzy, and Juvara.

ilium is smooth and can be readily adapted to the formation of a hip socket. The objections to this shelf include the fact that it is difficult to turn down a leaf of bone to the very edge of the acetabulum. Wedges of bone cut from the ilium and packed above such shelves may not prevent displacement of the shelf by muscular contraction and later weight-bearing. Failure to place or to maintain the iliac graft low enough over the reduced femoral head to stabilize the hip has occurred in some of our own cases and has been noted in the published roentgenograms of other surgeons, including Crego, Haas, and Hey Groves.

The following case report illustrates the unsatisfactory result which may be expected from shelving the unreduced hip.

Case I. M. H., a female, aged 43, consulted me in 1931 because of a marked waddle gait; lumbar lordosis; chronic backache and inter-

patient was born in Marash, Turkey, and although doctors had been consulted when she was a small child, she had not learned the nature of her disability.

Roentgenograms showed bilateral, high, and posterior dislocation of the femoral heads. (Fig. 2A.) Because the pain and disability were becoming more marked, surgery was recommended. In view of the age of the patient it was considered inadvisable to attempt to correct any of the upward displacement of the femur on the ilium. A bilateral shelving operation was planned. The first operation was carried out March 30, 1931. The shelf was constructed of bone from the ilium after shifting the position of the head of the femur more anteriorly. The anterior-superior spine was then removed and driven into the ilium as a wedge just above the depressed leaves of iliac bone. A similar operation was performed on the right hip April 14, 1931. These shelves have succeeded in preventing further displacement and have decreased moderately the acute

lumbar lordosis. (Fig. 2B.) The pain in the hips and the backache have recurred and at present are more marked than before operation. The

The use of the tibial peg shelf for the formation of an adequate primary acetabulum is illustrated by the following cases:
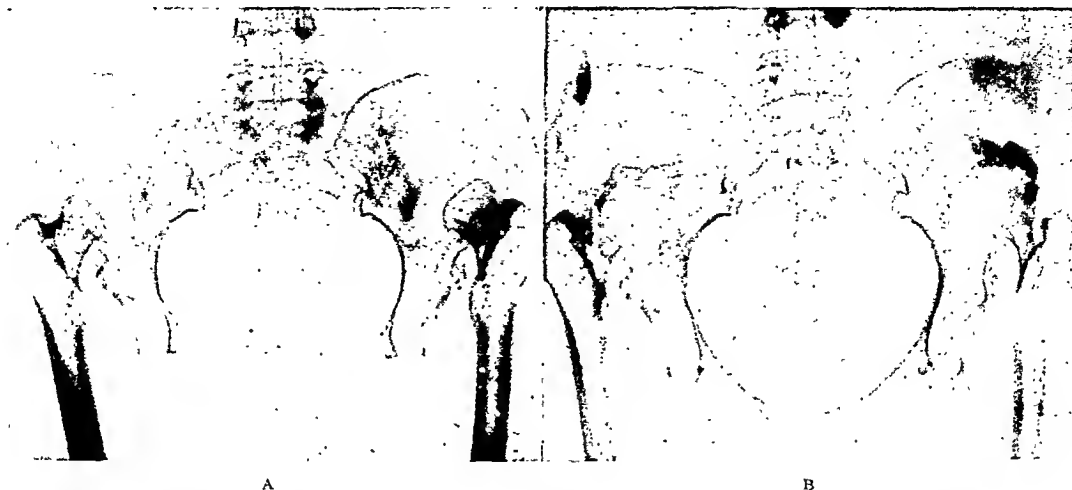
FIG. 2. Case 1. Female, aged 43 years, with untreated bilateral dislocation of the hips. A, before operation. B, five years after shelving the unreduced hips with bone taken from the ilium and supported by grafts from the anterior superior spine. The results have been unsatisfactory.

Trendelenburg and the waddle gait have persisted unchanged.

The improvement which resulted from this operation was too slight to justify the risk of a major operation.

Explanations for the unsatisfactory results of the shelf operation for the *unreduced hip* include:

1. Poor function of the muscles which abduct and stabilize the hip, because of short distance between their origins and insertions.

2. The fulcrum (articulation) is more lateral with respect to the midline of the body and the load placed on the hip abductor muscles is increased.

3. The secondary acetabulum is rarely entirely adequate.

4. Excursion of the head of the femur on the side of the ilium may produce degenerative changes, and cause pain when walking.

5. If the dislocation is unilateral the extremity will be functionally shortened, because of the upward displacement on the ilium.

6. The Trendelenburg and the limp are rarely corrected by the iliac shelf over an unreduced hip. (Fig. 3.)

CASE II. A. F., a female, aged 6, the daughter of a physician, was brought to the University of Chicago Clinics July 1, 1938. Bilateral dislocation of the hips had been recognized when she was 12 to 14 months of age. An attempt to accomplish a closed reduction was successful for the right, but not for the left hip. The right hip remained in the socket and continued to develop and function normally. Two and one-half years before her admission to the University of Chicago Clinics an open reduction of the left hip was attempted without success. One year later an attempt was made to stabilize the hip by turning down a shelf of iliac bone. This also was a complete failure. A third operation, in May of 1936, consisted of an osteotomy for the correction of torsion of the femur.

At the time of admission to this Clinic the physical examination revealed a bright, normal-appearing girl who walked with a marked limp when weight was borne on the left leg. The Trendelenburg was positive. Motion at the hip was free in all directions and the head of the femur could be palpated posterior to and above the level of the primary acetabulum. Roentgenograms showed external rotation of the shaft and posterior and upward dislocation of the head of the femur. (Fig. 4A.) The iliac shelf had undergone absorption until it was difficult to ascertain its location in the roentgenogram.

A program for reduction of the dislocation and stabilization of the hip was recommended. July 8, 1938, a Kirschner wire was inserted the blood supply to the femoral head. A roentgenogram twelve days after applying this fixed skeletal traction showed the position be-
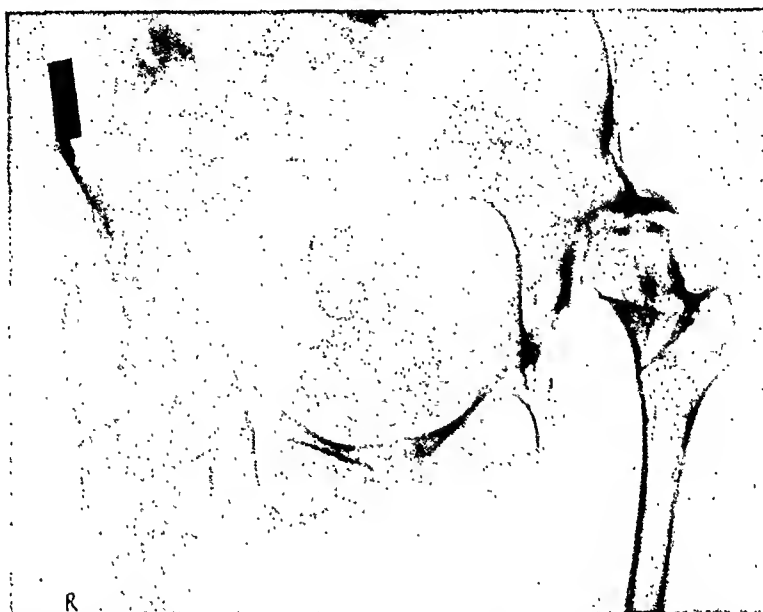
FIG. 3. Illustrates satisfactory reconstruction of an acetabulum by means of a tibial peg shelf over the head of an unreduced hip. Shortening of 1½ inches persists, although a growth arrest operation was performed on the distal right femoral epiphysis. The patient continues to limp and the Trendelenburg is positive. This end result is not so satisfactory as may be obtained when the hip is first reduced and then shelved.

A   B

FIG. 4. Case 11. Female, aged 6 years. A, dislocation of left hip, development of a secondary acetabulum, and a poorly formed socket. Attempts at both closed and open reduction had been unsuccessful. B, tibial peg shelf constructed at the superior margin of the primary acetabulum after open reduction of the hip which followed a period of skeletal traction.

through the left femur above the condyles. A plaster cast was applied to the body and the opposite leg and traction by means of a turnbuckle, as illustrated in Figure 5, was applied. Precautions were observed to prevent pulling the hip down too rapidly for fear of disturbing low the level of the primary acetabulum and an open reduction operation was performed on July 18, 1938. The primary acetabulum was found to be partly filled with soft tissue and obscured by folds of the capsule. The femoral head was slightly egg-shaped, but the cartilage

over it was smooth and appeared to be normal. The dislocation was reduced. A tibial bone shelf was constructed by means of three wedge-

passive motion at the knee and relaxed passive motion at the hip, was begun. Weight-bearing on the reduced hip will not be permitted for
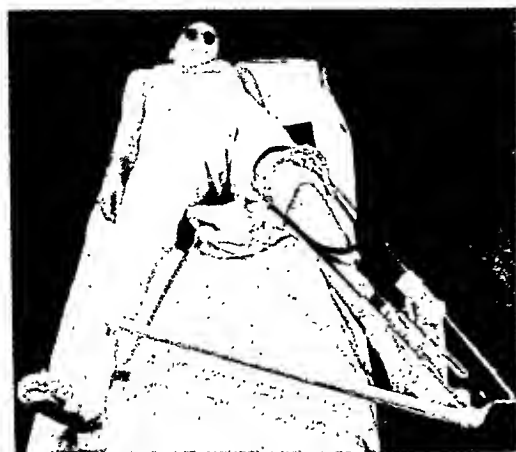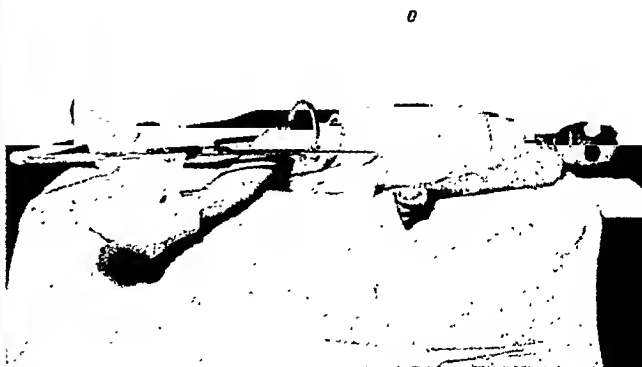
FIG. 5. An effective method for applying skeletal traction. Countertraction is obtained by the body and well leg cast in which is incorporated the ring of a Thomas splint. A heavy bicycle spoke has been passed through the femur of the dislocated hip just above the condyles. This is made taut with a light aluminum bow and traction is applied with a turnbuckle fastened to the end of the Thomas splint. Between the traction bow and the turnbuckle is an ordinary spring scale which registers the extent of traction in pounds. The pull is not permitted to exceed 16 pounds and the descent of the femur should be gradual, preferably carried out over a period of from three to eight weeks.
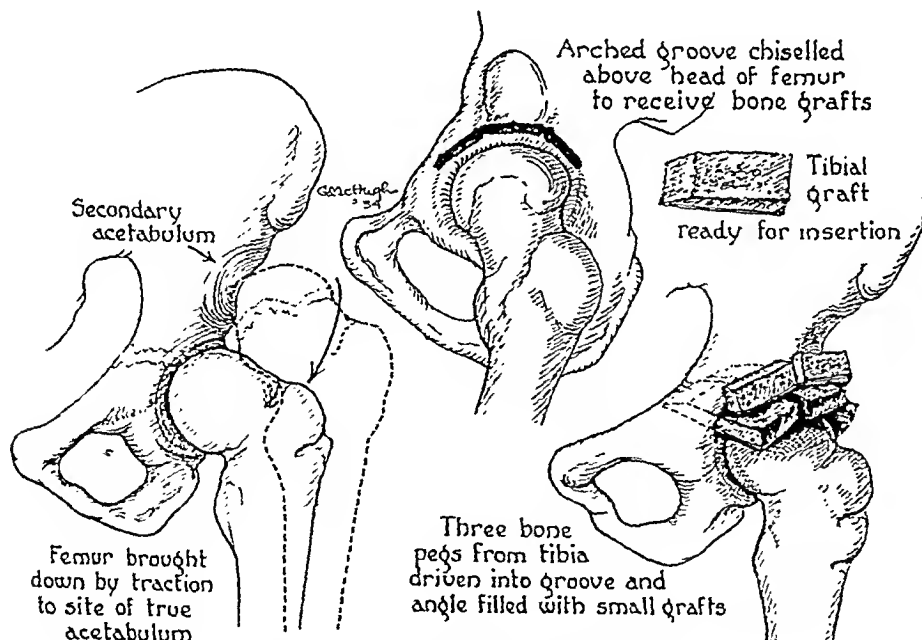
FIG. 6. Diagrammatic illustration of the tibial peg shelf. (From Compere and Phemister, in *J. Bone & Joint Surg.*, 17: 60, 1935.)

shaped grafts placed edge to edge and driven into the rim of the acetabulum. (Fig. 6.)

The patient was able to leave the hospital on the seventh postoperative day. Two weeks after the operation the cast was bivalved and physical therapy, consisting of active and

six months from the date of operation but in the meantime the child is walking with crutches and exercising the hip freely. (Fig. 4B.)

CASE III. H. B., a female, aged 12 had congenital dislocation of the right hip. This patient limped from the time that she first

began to walk and continued to do so until she was brought into the University of Chicago Clinics at the age of twelve, April 19, 1937,

tion, continued for from 3 to 8 weeks, (Fig. 5.)

2. After the hip has been pulled down to
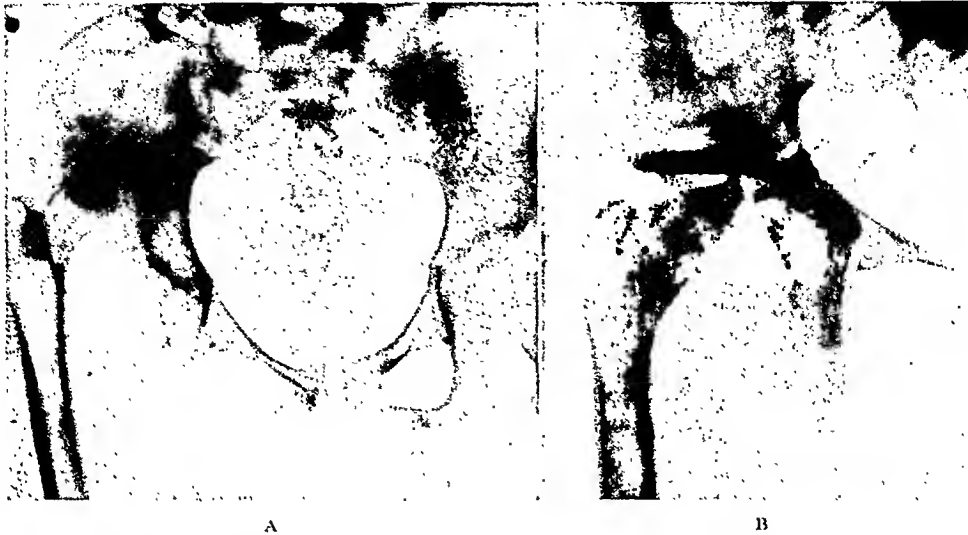
FIG. 7. Case III. Female, aged 12 years. A, high posterior dislocation of right hip, untreated. B, correction of upward displacement with tibial peg shelf in position above the partially reduced femoral head. (October 28, 1937.)

where the diagnosis was made. The roentgenogram also showed bilateral sacralization of the fifth lumbar vertebra with spina bifida occulta of the fifth lumbar and first sacral segments. (Fig. 7A.) The right femur and the corresponding half of the pelvis were underdeveloped. The right acetabulum was small and shallow. The parents refused to permit treatment at this time, but four and one-half months later, September 8, 1937, she was brought back to the hospital and an operation for open reduction and shelving of the hip was agreed upon.

A Kirschner wire was inserted through the lower end of the femur and the hip was slowly brought down into position, using turnbuckle traction for a period of six weeks. The open reduction was successful and a tibial peg shelf was constructed in the superior acetabular margin. (Fig. 7B.) Approximately three weeks after operation the cast was bivalved and passive flexion of the reduced hip was begun, while maintaining traction and a position of abduction. Function has continued to improve and the end result in this case promises to be satisfactory. (Fig. 7C.)

The several steps in the technique of treatment of congenital dislocation of the hip by open reduction and shelving operations may be listed as follows:

1. Correction of the upward displacement of the femur by gradual skeletal trac-

below the level of the primary acetabulum, an *open* reduction may be performed.

3. An anterior incision is made to expose the hip and the capsule is opened suffi-

FIG. 7C. Case III. Nine months after operation. There is now an adequate hip socket. A small fragment of one of the tibial grafts which was too long has become detached and lies posterior to the upper portion of the neck of the femur. Function of the hip is improving and prognosis for a satisfactory end result is favorable. (July 26, 1938.)

ciently to inspect the acetabulum and remove from it adherent folds of capsule, fibrous, or fatty tissue.

4. Reduction of the head of the femur to the primary acetabulum is accomplished by

further traction, abduction, and internal rotation. Skids or other traumatizing instruments should not be used.

7. A full thickness autogenous tibial graft ½ inch in width and 6 inches in length should be obtained by assistants and
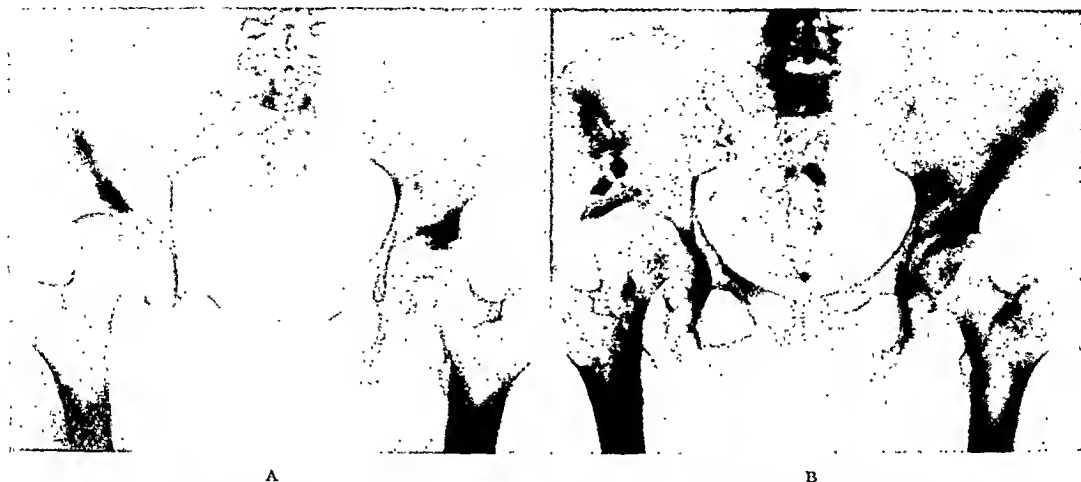
FIG. 8. Case IV. Female, aged 21 years. A, congenital inadequate right hip. B, following shelving with three full thickness peg grafts. The shadows of the additional tibial bone wedges are shown in the roentgenogram in the angle between the peg shelf and the ilium.

5. If the acetabulum is adequate no attempt is made to shelve.

6. If the acetabulum is shallow or the

FIG. 8c. Case IV. Roentgenogram of May 19, 1938, two years and four months after operation, showing the smoothly arched shelf which conforms to the contour of the femur. The joint space is narrow but the hip is stable, the motion is good, strength is normal, and the patient is able to perform her duties as a bank clerk without recurrence of the pain. After an evening of dancing or a hike in the country she may note a mild arthritis-like ache.

roof slopes sharply upward, a tibial peg shelf may be constructed at the superior margin, outside of the capsule of the joint.

divided into four segments 1½ inches in length. The edge of three of these grafts should be sharpened to resemble the cutting edge of a chisel.

8. Using first an osteotome and then a thick-bladed chisel which is placed at the superior rim of the primary acetabulum just above the reduced head of the femur and outside of the capsule, a deep arched groove is prepared for the grafts. The chisel should be driven into the edge of the acetabulum and on into the ilium for a distance of more than 1½ inch in a medial and upward direction.

9. Each of the three grafts is now driven firmly into the slot. One is placed slightly anterior, one directly above, and one slightly posterior to the head of the femur, with the edges of each of the three grafts in contact with the graft adjacent to it.

10. The remaining segment of tibia and additional bone from the ilium are now placed in the angle between the ilium and the firmly impacted tibial pegs.

11. The hip is inspected to ascertain that the capsule lies between the head of the femur and the shelf, and that the traction

which has been maintained during the operation, and is to be maintained for several weeks subsequent to the operation, is sufficient to keep the head from pressing either directly against the roof of the primary acetabulum or the tibial pegs. Such pressure may result in aseptic necrosis.

12. Passive flexion motion (without rotation) with the leg abducted at the hip may be begun in two weeks.

13. Active motion should be permitted and encouraged after four weeks, without releasing the traction.

14. Weight-bearing is permitted in the pool with water at arm pit level after three months.

15. Weight-bearing unprotected is not permitted until six months after the shelving operation.

The tibial peg shelf was described in 1935.[2] Included in that report were patients whose unreduced hips were shelved with the tibial peg technique. When these patients whose hips were not reduced before shelving are now studied and the end results are measured by the following yardstick, the improvement noted is too slight or too questionable to justify the risk or inconvenience of the operation.

CLINICAL YARDSTICK FOR MEASURING RESULT OF TREATMENT FOR DISLOCATION OF THE HIP

	Per Cent
1. Freedom from *pain* when walking........	20
2. Functional range of active and passive motion in all directions................	15
3. Stability (no tendency to subluxate when weight-bearing).....................	20
4. Negative Trendelenburg Sign...........	15
5. Noticeable decrease in or absence of limp when walking..........................	15
6. Length inequality of less than 1½ inches.	15
	100

The postoperative result which can be graded 90 per cent to 100 per cent is excellent. A rating of 80 per cent may be considered a good result, while any procedure which does not offer a reasonable prognosis of functional recovery of more than 60 per cent, as graded by this test, should be condemned and discarded. From my experience and from observations of the patients treated by other surgeons, few of the shelf operations for the *unreduced* hip can be graded 70 per cent satisfactory. The well placed iliac shelf may bring about a decrease in the lordosis of the lumbosacral spine, but this alone is not considered a satisfactory end result.

Technical reasons for unsatisfactory results from the shelving operation include:

1. Placing shelf too high above the femoral head, permitting subluxation.

2. Forced skeletal traction with rapid descent of the upward displaced femur may tear the capsule of the joint or constrict blood vessels to the femoral head, resulting in aseptic necrosis.

3. Unwise use of heavy metal skids at the time of attempting to complete the open reduction may traumatize and devitalize portions of cortex of the femoral head or of the acetabulum.

4. If traction is not maintained after reduction, the pressure of the reduced femoral head against the acetabular roof or the tibial peg shelf may cause necrosis with absorption of articular cartilage or subchondral bone.

5. Trauma to the cartilage of the superior acetabular rim of a young child, produced by the chisel or the tibial bone grafts, may result in growth arrest of the iliac portion of the acetabulum.

6. The shelf of bone may project laterally to the level of the trochanter and decrease the effectiveness of the gluteus medius muscle.

The shelf operation is also indicated for the reconstruction of the congenitally inadequate acetabulum, when, during adult life, the hip becomes painful.

CASE IV. D. C. A female, aged 21, came to the University of Chicago Clinics November 11, 1935, complaining of pain in her right hip of two years' duration, but present only when she walked or exercised. She described it as a sharp ache with a tendency to radiate down the thigh. The pain was more marked at the end of the day and increased in direct proportion to the amount of walking which she was required to do.

Examination revealed limitation of flexion of the right hip at about 90 degrees and attempts to force this or to abduct or rotate the hip elicited pain. There was no swelling, redness, heat, or local tenderness.

A roentgenogram revealed a very shallow acetabulum, a moderate degree of coxa valga and subluxation upward and outward of the right femoral head. (Fig. 8A.) A diagnosis was made of congenital inadequate right acetabulum, with subluxation of the right hip. January 22, 1936 three tibial bone pegs were driven firmly into the edge of the acetabulum above the head of the femur. Additional bone was placed above the shelf. (Fig. 8B.) The cast was bivalved fifteen days after operation, and flexion motion with the leg maintained in an abducted position was begun.

She was discharged from the hospital walking with crutches twenty days following the operation, but was not permitted to bear full weight on the shelved hip for three months. The limp gradually disappeared and range of motion became approximately normal. One year and six months after operation function was excellent. There was no limp, no Trendelenburg, and no pain except after unusual exertion such as dancing or hiking. Strength appeared to be normal. A roentgenogram made September 11, 1937 showed some areas of decreased density in the head of the right femur, suggesting beginning aseptic necrosis. The cartilage space was also slightly more narrow on the operative side than in the normal hip. The patient was advised to favor the leg and not use it more than she found really necessary. She has continued to be able to work and to maintain her usual degree of activity. Roentgenograms of May 19, 1938 show improvement in the trabecular architecture of the femoral head and an adequate acetabulum. (Fig. 8C.) Three years after operation the patient is physically active and has essentially normal function in the hip.

Cases II, III, and IV illustrate the following advantages of the *tibial peg* shelf:

1. The wedge-shaped grafts can be accurately placed in the rim of the acetabulum in a direction obliquely upward and inward.

2. The grafts are of *strong* cortical bone, are not easily displaced, and the period of immobilization is shorter than when bone from the ilium is used for the shelf.

3. Such grafts undergo transformation, fuse together and form a smooth, arched, weight-bearing surface which will support the thrust of the head of the femur.

SUMMARY

A shelf operation is indicated when the acetabulum is found to be inadequate. It is not the operation of choice for the unreduced hip. The tibial bone peg shelf is favored because it creates a firmly anchored, strong shelf which can be accurately placed at the superior acetabular margin.

Reduction of the congenital dislocation of the older patient should be preceded by a period of gradual skeletal traction. Open reduction and construction of the shelf should be accomplished with minimal trauma to the articular surfaces. Early motion following operation should be aided and encouraged, but full weight should not be borne until six months after construction of the shelf.

The indications for, contraindications to, and the technique of the shelf operation have been described. Factors which may explain the failure of the shelf operation to correct the limp and permit painless motion with strength and stability in some patients subjected to this operation have been discussed.

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THE OPERATIVE CORRECTION OF EXTERNAL ROTATION CONTRACTURE OF THE HIP*

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EXTERNAL rotation contracture of the hip is an uncommon deformity, easily distinguished from the not uncommon external rotation position of the paralytic lower extremity. This position is conditioned by gravity, the weight of the limb, and the greater strength of the muscles of external rotation. External rotation position may be assumed to give greater stability to the limb in walking, but the position in external rotation does not reach 90 degrees as it does in external rotation contracture. Operative procedures for the correction of external rotation position have been devised by Davis, Loeffler, and Bristow.

The contracture in external rotation is due to soft tissue contracture, and it is impossible to turn the hip into internal rotation, which would be possible in external rotation position. The soft tissue change is mainly a contracture of the lower, obliquely coursing muscular and tendinous fibers of the gluteus maximus, together with a lesser contracture of the six small external rotating muscles of the hip and tightness of the posterior capsule of the hip joint. The operative procedure must release each of these elements of deformity.

Some degree of pelvic obliquity is associated with this contracture, but the contracture does not cause the pelvic obliquity. It may be present on either the low or the high side of the pelvis but in the paralytic pelvis is usually on the low side. Two cases of fixed paralytic pelvic obliquity have been observed by Mayer in which a secondary contracture in external rotation existed on the low or abducted side of the pelvis. This was overcome by section of the tendon of the gluteus maximus. (No soft tissue contracture in external rotation can exist without some measure of abduction contracture. The thigh, once rotated externally and fixed, becomes abducted by the secondary abductor action of the gluteus maximus in its oblique portion despite the usual normal action of this part of the muscle as an adductor [Gray]. It is quite rare for external rotation contracture to develop on the side of primary abduction contracture in fixed pelvic obliquity.)

The operation for correction of external rotation contracture on the high side of the pelvis was devised for a boy of 12 who had been paralyzed from the waist down ever since birth, either because of a birth injury or because of a congenital myelodysplasia of the spinal cord. There was a marked right dorsal and lumbar scoliosis. The left iliac crest was elevated 1½ inches. The left thigh was held continually over the right, so that the right thigh presented a concavity for the reception of the anteriorly bowed left femur. The left hip was held in 80 degrees of fixed flexion. The left thigh was outwardly rotated about 90 degrees, in about 20 degrees of abduction. No internal rotation was possible. The right hip showed a flexion deformity, and both knees were flexed.

Stripping of the flexors of the hips overcame the flexion deformities of the hips. A soft tissue operation overcame the flexion deformity of the right knee and a supracondylar osteotomy the deformity of the left knee. The deformity in external rotation of the left hip was now obvious. It was corrected on October 14, 1934 without any

anesthesia since the boy was anaesthetic from the waist down.

TECHNIQUE OF OPERATION

An 8 inch longitudinal incision was made just posterior to the greater trochanter, extending from about 1 inch above the level of the greater trochanter, parallel to the shaft of the femur, to about an inch below the tendinous insertion of the gluteus maximus. The subcutaneous tissues were undercut to expose the muscle better. On attempted internal rotation, it was seen that the tendon of the gluteus maximus offered great resistance to internal rotation. This tendon was then cut between clamps. The very atrophic oblique fibers of the muscle were also included. The extent of division of the tendon and muscle reached almost to the greater trochanter. A large part of the external rotation contracture was now overcome and it was evident that this muscle had played the greatest part in the causation of the contracture.

A longitudinal incision was made in the periosteum over the trochanter, and the soft tissues in the region of insertion of the short external rotators were carefully stripped back for half an inch or more. The posterior portion of the capsule of the hip joint was cut perpendicularly to the axis of its neck and stripped along its neck. It was now possible to correct the deformity completely. The hip was put in a cast for three weeks in full internal rotation, a position which was easily maintained without any tension whatsoever. The abduction position of the limb offered no difficulty in correction after division of the tendon of the gluteus maximus. Nothing was done to the gluteus medius. The wound healed by primary intention and the postoperative course was uneventful.

The correction of this deformity was maintained. Spine fusion was done after the straightening of the spinal curve in the wedged turnbuckle jacket.

The boy died of pneumonia on February 6, 1936. Autopsy indicated that the severe myelopathy was due to meningeal thicken-

ing, especially in the lumbar region of the spinal cord, and compression of the vessels of the spinal cord.

Rechtman of Philadelphia has used this operation twice. The first case was that of a child, 3½ years old, who had multiple congenital deformities, including a congenital dislocation of the right hip and an external rotation contracture of the same hip of 90 degrees. The right side of the pelvis was elevated. Some time after the reduction of the hip, the soft tissue contracture in external rotation was released by the operation described. A plaster spica held the hip internally rotated for four weeks. At the end of this time, a special bar devised by Rechtman helped to keep the hip internally rotated. The child's condition has been greatly improved.

His second case represents an extension of this operation. He saw a man who two years before had had a delayed reduction of a traumatic dislocation of the hip, with resultant necrosis of the head of the femur. Because of disability in the knee and foot of the same side, the marked external rotation deformity of the entire limb was corrected by this operation. Balancing of his lower extremity improved his condition tremendously.

The operation is not meant to correct an external rotation deformity due to intra-articular pathology within the hip. Ordinarily, a subtrochanteric osteotomy or some hip joint operation, as arthrodesis, is used. It may then be possible in some cases to use this operation where a bone operation would be ordinarily used.

SUMMARY

External rotation position of the hip is differentiated from external rotation contracture. An operation for the relief of this contracture is described.

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RECONSTRUCTION OF TOP OF FEMUR (LEVER) OR ITS ELONGATION IN PARALYTIC CONDITIONS

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THE influence upon hip function of the lever at the top of the femur (head-neck-great trochanter) is of great importance and identical in mechanical principle to that of the olecranon process at the elbow. However, judging from a careful survey of the literature, this has never been appreciated nor has it received any attention. No suggestions have ever been made surgically to modify or reconstruct the length of either, when the necessity has been evident. I have elongated both the olecranon and the top of the femur in a large number of cases. In the case of the olecranon, to which only one muscle (the triceps) is attached, the function of extension is either restored when completely absent or it is strengthened when diminished, whereas in the case of the top of the femur-lever, the function of eight muscles is involved, together with the function of active weight-bearing, as well as abduction, inward and external rotation, or, in other words, stabilization of the hip joint. (Fig. 1.) Briefly, such necessity may arise from this lever being shortened as:

1. From congenital maldevelopment which occurs so frequently as a feature of congenital dislocation of the hip.

2. In destruction from:

    (a) Acute epiphysitis of infancy or later life.

    (b) From healed tuberculosis (or other pathologic process) where a varying degree of motion persists with marked adduction deformity and its incidental shortening. In such cases, it has always been taught that the correction of the deformity by Gant's or similar osteotomy was of no avail because of the postoperative return of the deformity. Therefore, such cases have been treated by an arthrodesis operation associated with correction of the deformity—an unnecessary destruction of the joint, as it has been proved. It is now apparent that the reason the deformity recurred following osteotomy in such cases was that the abductor muscles were impotent because of the shortened lever at the top of the femur and were not able to resist weight-bearing plus the unimpaired action of the adductors which slowly pulled the limb back to its old position. In such cases, under the present concept, the leverage at the top of the femur should be lengthened, either at the time of correction by osteotomy or later, so that a proper balance may be established between the abductors and the adductors. Under such conditions, the motion at the hip is preserved at the same time that relapse of the deformity is prevented; and the functions of active weight-bearing and adduction-abduction are restored. (Fig. 2.) In some of these cases, both of congenital and pathologic origin, there has remained a bone block at the superior periphery of the hip joint which can be removed at the same time with the lengthening of the lever, in order to allow freedom of hip joint motion.

3. From trauma—where this principle is more frequently applicable than in any other condition. I am referring to nonunion

time. It is usually preferable to wait to a later date—particularly in border-line cases where it is doubtful whether the secondary

Fig. 1. X-ray and key schema to illustrate cases of old reduced congenital dislocation of the hip with marked shortening of the lever at the top of the femur indicated by line at b. Bone block to abduction is indicated at a in schema.

Fig. 2. Same case as Figure 1, showing removal of bone block to abduction as well as more than doubling the length of the lever at the top of the femur, a-d, by rectangular bone graft, b, from outer table of ilium at anterior superior spine at c.

of fracture of the neck of the femur, where so much bone absorption from lack of blood supply has occurred that a bone graft peg operation is not feasible. It is, therefore, necessary to reconstruct the joint. In many instances the absorption has been so extensive that the top of the femur may not be more than one third of its anatomic length. In such cases, my reconstruction operation is done and the femoral head after removal is transferred into a wedge and used to reconstruct this lever. (Fig. 3.)

4. In cases of arthroplastic operations to restore motion to a bony-stiff hip joint where the top of the femur has been severely shortened, both by the destructive lesion which produced the bony ankylosis and by the necessary removal of bone in modeling the new joint. It is up to the judgment of the surgeon whether he restores the length of the top of the femur at the primary operation of making the joint, or whether he defers it to a later

operation will be necessary or not. The absence of adequate active weight-bearing or abduction function will indicate the wisdom of the second step.

In cases where the disease has been cured in tubercular or other conditions by extra-articular tibial bone grafts, if arthroplasty has been deemed a safe procedure, the elongation of the lever can be provided for at the primary arthroplastic operation by leaving in situ as much of the trochanteric portions of the original grafts as the surgeon wishes. (Fig. 4.)

5. The fifth and last general application of this kinesiologic principle of the restoration of the hip joint and active weight-bearing function has been in cases where there has been a weakening by infantile paralysis or by other cause of those groups of muscles attached to the tip and outer surface of the great trochanter, which function as weight-bearing and abductor muscles. These muscles are seven in number, namely: the gluteus medius and

minimus, the obturator extensor and internus, the two gemelli and the pyriformis. (Fig. 5.) Further, it should be pointed out

its elongation are double, namely, the muscle force which activates it has been lessened below functional capacity, and,
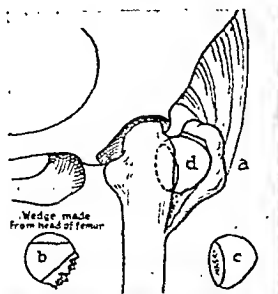
FIG. 3. X-ray to illustrate method of lengthening lever at top of femur, by using head of femur *b*, transformed into wedge *c* and *d* in author's reconstruction operation in ununited fracture of the femur with marked neck absorption.

FIG. 4. This x-ray with key schema illustrates method of providing top of femur lever when doing an arthroplasty to restore motion at hip, following arthrodesis by tibial bone grafts. When removing grafts to restore motion, their lower ends are left at *a*. The portions of grafts shown in dotted lines are removed when joint is modelled.

that the change brought about by the mechanical set-up as a result of the elongation of the top of the femur determines that those muscles which function both as abductors and external or internal rotators become more pronounced abductors or weight-bearing units. This is also true of the tensor vaginae femoris muscle (which is not attached to the trochanter) because of a change in line of pull.

In paralytic cases, one might unwittingly reason that the lever would be of normal anatomicophysiologic length, but this has not been found to be the case at all. The weakening of the trochanter muscles has resulted, as one might expect in a general lack of development of the whole upper end of the femur, and this has caused a diminution in the longitudinal dimensions of this lever. Therefore, the indications for

at the same time, the lever has become shortened. The surgical results from reconstructing this lever, as might be anticipated, have, in many cases been brilliant. (Fig. 6.)

In a newly surgically made hip joint, as well as in cases of the reconstruction operation for nonunion with absorption of the neck of the femur, a postoperative dislocation may even occur, because of the inadequate length of this lever. The pelvis may tip upward, or the femur pull inward in adduction with varying resultant practical shortening of the limb or weight-bearing weakness with a marked limp. Such a limp has often been misunderstood for that of limb shortening. Many patients have been brought to the author with a request that the limb be lengthened, when there was little bony shortening of the limb.

The contrast in favor of the importance of the lever at the top of the femur compared to that at the elbow is even greater, when they have been shortened by disease, trauma, inadequate development, etc.

In these instances, it is assumed that the
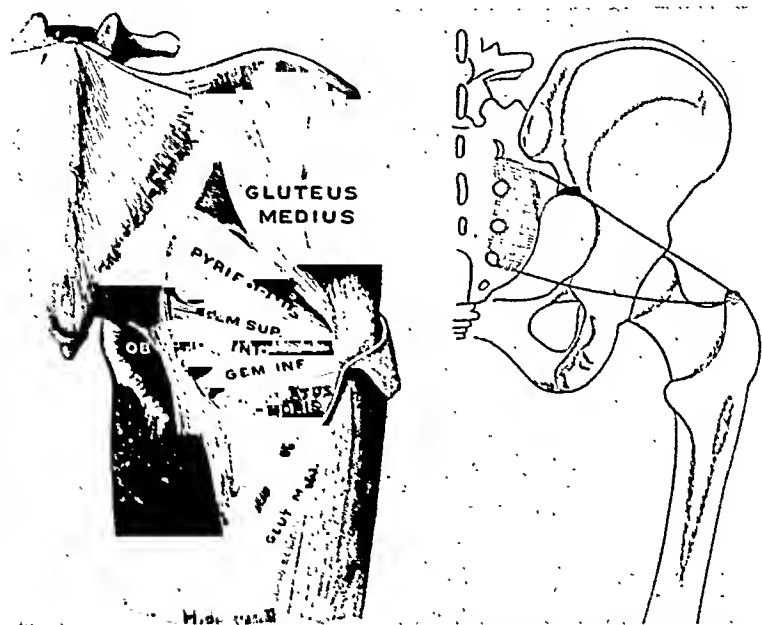
Fig. 5. Drawing (after Testut) from Gerrish anatomy, illustrating origins, insertions and anatomic contours of hip abductors and weight-bearing muscles.

in that the olecranon process functions only to enable active extension, whereas the lever at the top of the femur is the essential element in providing a mechanical apparatus not only for abduction and inward and outward rotation of the lower limb at the hip, but for the stabilization of the hip joint and the active control of the weight-bearing relationship between the femur and the pelvis. There is one muscle inserted into the olecranon process, while there are seven muscles inserted into the outer end of the lever at the top of the femur. In addition, the stabilizing of the tensor vaginae femoris is also increased.

Just as in industry or in everyday life, if the force available to be directed upon the end of a lever is inadequate, and it cannot be increased, then the only recourse remaining is to elongate the lever so that the same available force will be adequate to the lifting necessary. This same principle I have applied in the case of both the olecranon process and the lever at the top of the femur—that is, to lengthen these structures to their anatomic dimensions

muscle force is physiologically normal. On the other hand, when the muscle forces which normally activate these levers have been weakened from any cause whatsoever, particularly infantile paralysis, then it follows by the same token that the elongation of these lever structures beyond their anatomic normal dimension is equally indicated. The results obtained by such surgical procedure have been most gratifying. This principle was first applied by the author over twenty years ago in cases of ununited fracture of the neck of the femur where extensive absorption of bone had occured (reconstruction operation).

A shell of bone obtained from the superior and outer surfaces of the great trochanter about 3½ inches long is turned outward with the muscle insertions undisturbed and into the crotch thus made, the removed head of the femur transformed to the shape of a wedge is placed, the purpose being to afford a longer lever for these muscles to pull upon. Thus postoperative dislocations are prevented and, abduction and active weight-bearing are restored.

TECHNIQUE

1. For many years following the introduction of my reconstruction operation of

this purpose. This massive wedge, when properly placed, immediately supports the lever in its elongated state and serves forth-

FIG. 6. Demonstrates the lengthening of the lever at the top of the femur by more than 50 per cent in a case of infantile paralysis with weakened abductor and weight-bearing muscles.

the neck of the femur, published in 1919, I have devoted myself intensively to the development of the simplest surgical technique for all occasions in lengthening this lever. The availability of bone graft material is almost a determining element in the design of the special technique. The desire is to have a massive graft which will not only serve eventually to fuse in place and reconstruct the lever, but will immediately elongate the lever by its mass support. In the instance of the ununited fracture of the neck of the femur, the removed head of the femur serves this purpose admirably. Formerly, I always threw it away and used numerous small fragmented bone grafts, but during the past ten years or more, I have shaped it into the form of a wedge, using motor-saw and osteotome for

with to prevent the dislocation of the newly formed femoral head from the acetabulum. Because of its extensive mass, it allows ample leeway in shaping the desired size wedge. Only three weeks of postoperative immobilization have been necessary, thus allowing free joint motion to be much more easily restored. When fragmented grafts were used, it was necessary to immobilize by double plaster of Paris spica cast for a long period (at least eight weeks) in order to allow time for the grafts to unite firmly and consolidate the new lever. (Fig. 1.)

2. In some cases the neck of the femur has been shortened due to ancient cured disease or to congenital malformation, or to former arthroplasty where the destructive lesion that produced the bone tuberculosis and the removal of bone made

necessary in modeling a new joint combined to produce the shortening. The bone graft material in these cases can be obtained from the side of the ilium, always high up at the crest, preferably at the anterosuperior spine, so as to minimize the disturbance either to the muscular structures or their innervation. It can also be obtained from the antero-internal surface of the tibia, always one of the most satisfactory sources of bone graft material. At the discretion of the surgeon, this lever may be elongated during the primary operation to produce motion in a bony stiff joint. In this instance, the side of the ilium has been already laid bare, and therefore the material for the elongation of the lever can be easily obtained. Formerly I obtained the grafts from the side and crest in the form of two "pieces of pie" (segments of a circle) consisting of the outer half of the crest and the outer iliac table, of proper shape and size to fill in the bony wedge cavity produced by the turning out of the shell bone from the tip and side of the great trochanter. These may be fastened together with a bone graft peg.

The technique which I employ at present is to obtain the graft in the shape of a square or a rectangle from the outer table of the ilium, including the outer half of the crest. This is placed in accordance with (Fig. 2) and immediately supports firmly the lever in the elongated state.

The technique for infantile paralysis is precisely the same. However, one caution should be firmly adhered to—if the graft is obtained from the outer surface of the ilium, it should be from the extreme upper anterior border, including a portion of the crest in order not to disturb the weakened muscles more than is absolutely necessary.
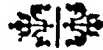
LEG LENGTHENING

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UNEQUAL lower extremities have a twofold deleterious effect upon the patient—mechanical and cosmetic.
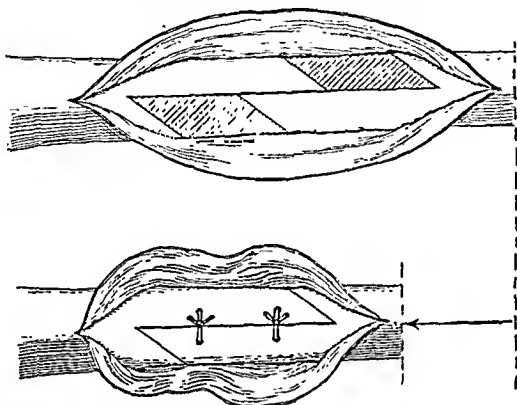
FIG. 1. z-excision to shorten femur or other long bone, and kangaroo suture of fragments.

The problem of correcting the disability has been in the minds of surgeons, and especially of orthopedists, for many years. Attempts to equalize the extremities have often been made through conservative means, i.e., building up the sole and heel of the shoe on the affected side.

A difference greater than three-quarters of an inch is often detected by the limp of the individual. And with greater differences the normal mechanics of the body are offset so that a vicious cycle is created. The shortened limb gets less and less physical strain in walking, as most of the weight and function is carried by the longer limb. As a result there is stimulation to the longer and further incentive to shortening of the other. Scoliosis, with resultant poor posture, is a common end result of inequality of the lower extremities. With these changes, there is a whole gamut of internal and somatic reactions from which patients seek relief.

In the victims of poliomyelitis such developments are more common and, of course, more severe because of the secondary muscular involvement—paresis to paralysis.

The muscle sense through a regular soled shoe is much more acute than through cork build-ups, especially where 2 or 3 inches of sole are necessary. Even in the poliomyelitics the mechanics of the entire body may be assisted through proper skeletal equalization. Especially is this true in flail knee cases. Such patients, with arthrodesed ankles, can lock their knees in extension when walking. One can dispense with braces with lock devices. A cork build-up of 2 or 3 inches, and in many cases less, will not permit such locking at the knee. The lever action of the foot is lost because of the built-up.

The public at large has not reached a stage in which it will readily accept the cork, leather and metal braced employee who is seeking work. Appearance counts for a great deal in obtaining the opportunity to demonstrate that one can do as well or better than the physically unhandicapped individual on the same job. It is therefore up to the surgeons to continue to perfect their techniques or accept those of others to obtain the more physiologic (skeletal) increase in length. Such lengthening will aid the job-seekers, where artificial soles can only hamper him.

Unfortunately, because of many factors —cumbersome apparatus, operative trauma and mismanaged postoperative convalescence, leg equalization by lengthening has been given up by many for leg shortening, a more simple operative procedure. This, however, should not decide the operation for the patient. An open operation carries a certain risk. A patient should

be permitted to have one good leg to stand on. For that reason and for the more normal physiology obtained, the equaliza-

braces, extend over a year. Their argument that leg lengthening also carries a long convalescent period and that therefore
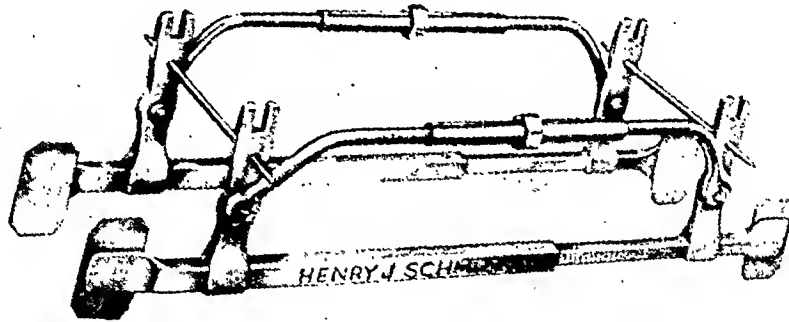
Fig. 2. Apparatus used for leg lengthening.

Fig. 3. Plastic osteotomy of tibia. ab equals a'b'. aa' equals 2ab.
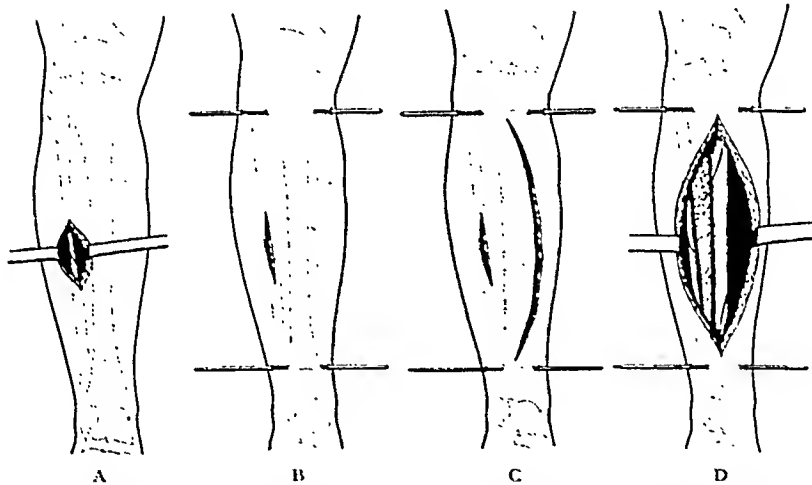
Fig. 4. a, open osteotomy of fibula, middle third. b, insertion of Steinmann nails into tibia. c, long semilunar skin incision over anteromedial surface of tibia. d, spiral incision of periosteum of tibia.

tion should be obtained by lengthening in the affected side.

When one witnesses the surgery of femoral shortening by some of those who are giving up leg lengthening, one soon realizes the many mechanical shortcomings of this procedure. These surgeons remove a cylinder of femur and rely on only the cross-section contact for union in the presence of marked resultant atonicity of the thigh muscles. It is no wonder that the convalescent period, with plaster and

the femoral shortening is more advisable, is not consistent. A z-excision with kangaroo suture of the fragments would improve the technique if the shortening operation must be undertaken. (Fig. 1.) I have used this procedure to shorten limbs when overgrowth is on the affected side. Solid union is obtained in eight weeks.

If surgeons would study the problem seriously and become familiar with the tissues that must be handled in preparation to lengthening their results would be

better. Lengthening should be performed in selected cases, and the patients should try elevated shoes in order to correct caliber. If this is done too rapidly thrombosis may result in the distal portions because of the diminished rate of flow.
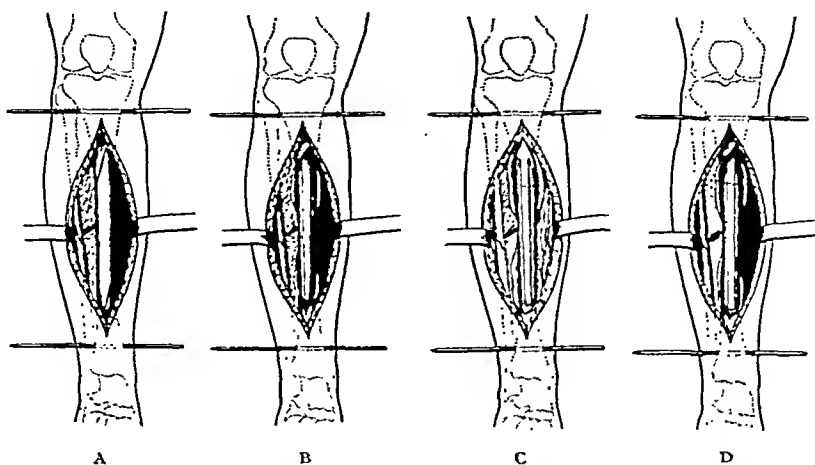
FIG. 5. A, incision of interosseous membrane. B, two long circular saw incisions at right angles to the anteromedial surface of the tibia. C, two saw cuts from upper ends diverging to periphery of tibia for a distance equal to increase to be obtained. D, completion of plastic osteotomy—cross cut anteromedial surface of tibia between lower ends of long incisions.
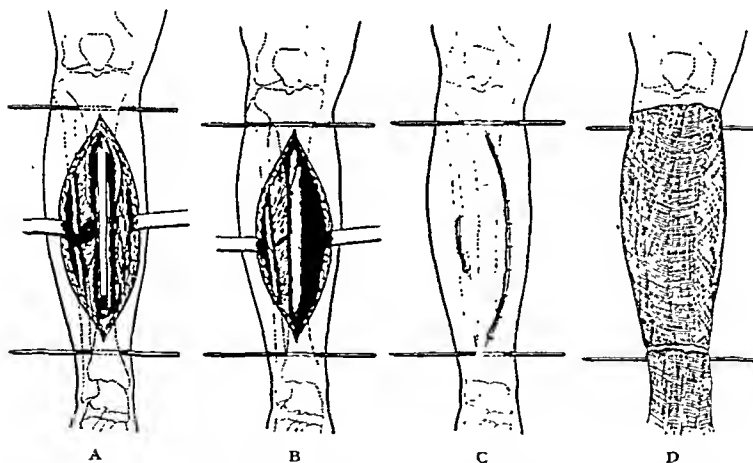
FIG. 6. A, tested for break in continuity. B, several interrupted sutures in periosteum. C, skin wounds closed with plain o catgut. D, vaseline gauze dressing including upper pin and up to lower pin. Separate vaseline dressing to foot including the lower pin.

secondary conditions such as scoliosis before the operation on the extremity is undertaken.

The physiology and function of the tissues to be lengthened must be kept in mind. Trauma of the structures at operation might produce a poor end result because of ensuing complications. The arteries must be remembered, since as they are stretched the lumen decreases in

Experience has shown that if the limb is kept elevated above the patient's heart level to ease the venous and lymphatic return and that if the lengthening process is gradual, no circulatory complications will result. Increase of length of not more than $\frac{1}{32}$ inch twice a day has been accepted by the writer as a safe procedure in actual practice. Under similar conditions peripheral nerve function has not been

interfered with. This is true in non-poliomyelitic cases.

After the leg lengthening operation has

Fig. 7. a, thin sterile dressings. b, circular plaster including knee, upper pin, and operative area up to lower pin. Separate plaster for foot including the lower pin. c, application of apparatus medially and laterally to pins. d, incorporation of apparatus to the casts with plaster.

been decided upon, the operative technique and apparatus should be considered. Any apparatus familiar to the surgeon that will retain the fragments in a functional alignment during the process of gradual lengthening and thereafter until union has taken place is satisfactory. One should, however, also consider the nursing problem and the safety of a patient while at the same time preventing any damage or interference to the operation. Many of the apparatus used are too cumbersome. Patients cannot move while the apparatus is in use.

The writer has designed a simple leg lengthening apparatus combined with plaster of Paris technique that answers the purpose admirably. The fragments are held in practically anatomic position if a simple rule in applying it is remembered. It remains as part of the circular plaster until union is demonstrated by x-ray. And because of lightness and its control of the operative site the patient can be moved about with ease. If necessary, he can be permitted to slide down a chute in case of a fire alarm, with safety to life and limb.

The apparatus consists of two Steinmann nails, one for each fragment. Two

isometric parts of the apparatus proper consist of telescope tubes, the inner one calibrated. These have posts attached between which is a turn-buckle arrangement for lengthening after the set is applied to the Steinmann nails and fixed with
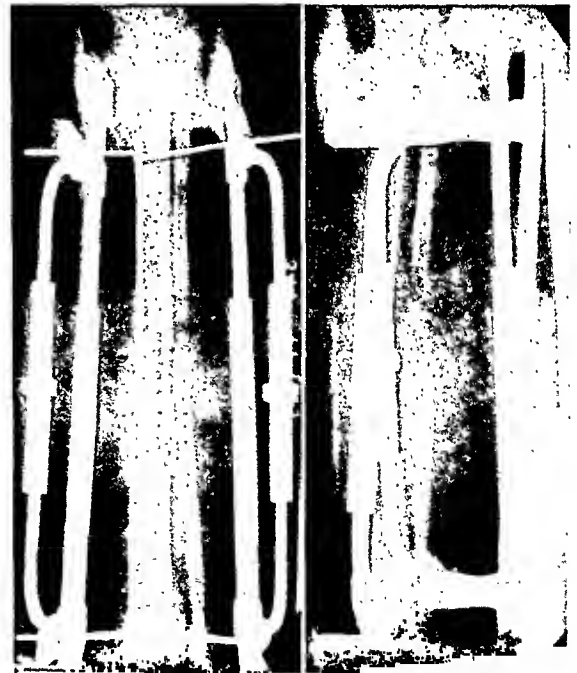
Fig. 8. X-ray at end of lengthening. Shows fragments in good alignment although lower pin broke.

plaster. There is a simple gauge—a flat piece of metal with a hole at each end so

distanced as to give the distance between the end posts when the instrument is closed or at zero.

parallel to the crest of the tibia. This is very important for obtaining a resultant functional alignment. When properly car-

FIG. 9. Photograph taken just before patient returned home. Turnbuckles had not yet been covered with plaster.

The writer has found this procedure successful in obtaining an average increase of length of 2¾ inches in tibiae. The steps of the operation follow. The operation is performed with a tourniquet applied well above the knee. The order of the steps is important.

1. Open osteotomy of fibula at junction of the lower and middle third.

2. Subcutaneous tenotomy of tendon Achilles in contracted cases.

3. Insertion of the Steinmann nails parallel to each other and in a plane

ried out in practice the alignment has been practically anatomic. The nails are distanced apart with the aid of the simple guide.

4. Semi-eliptical skin incision on antero-medial surface of the tibia is made between the nails.

5. The periosteum is cut in modified spiral to permit proper retraction while doing the plastic osteotomy and later to produce a periosteal tube.

6. With great care the interosseous membrane is then severed. The line should

be between the break in continuity of the periosteum on tibia and the osteotomy in the fibula.

7. Having by now the break in continuity of the fibula, interoseous membrane and periosteum of the tibia, the next procedure is the plastic osteotomy of the tibia. This consists of the following steps. Two long saw cuts, slightly closer together distally, about ½ inch apart, and twice as long as the increase in length desired, are made into the anteromedial surface of the tibia, i.e., if the increase is to be 3 inches, the long saw cuts must be 6 inches long. With the same Albee saw two cuts are made from the upper ends of the long cuts diverging towards the periphery of the tibia for a distance equal to the increase to be obtained. These latter incisions are connected subperiostelly (posterolateral aspect of tibia) with a Gigli saw. The plastic osteotomy is then completed when the two long incisions are connected by a saw cut at their distal ends.

8. At this point a test for complete break of continuity of the necessary tissues is checked upon by pulling the Steinmann nails apart. If the procedure has been carried out carefully the fragments of the tibia can be pulled apart about ¼ inch without very much tension.

9. The wound is now closed. The periosteum is sutured with several interrupted No. o chromic catgut sutures. The skin is closed with No. o plain.

10. Vaseline gauze dressing is applied in two parts. One includes the upper pin region, the knee and leg up to the lower pin. Care must be taken not to include the lower pin in the first part. The second part includes the lower pin region and foot. The gauze dressing is applied similarly in two sections.

11. The circular plaster dressing is also applied in two parts just as the vaseline gauze and gauze dressings. The break in continuity is just above the lower pin.

12. At this point the isometric parts of the apparatus are applied to the pins medially and laterally and fastened with plaster bandages to the circular plasters already applied.

The patient is returned to his bed with
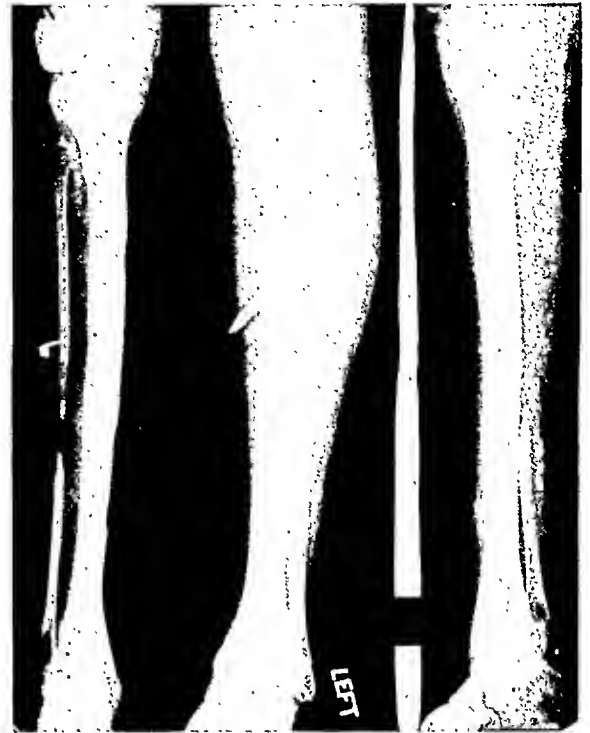
FIG. 10. End result compared to patient's normal leg.

instructions to have the extremity elevated. The turnbuckles for lengthening are turned about twelve hours postoperatively. The turns are made twice a day to obtain $\frac{1}{32}$ inch increase or $\frac{1}{16}$ inch in twenty-four hours. With this amount of increase the writer has had no morbidity or mortality. The average total lengthening has been $2\frac{3}{4}$ inches in patients ranging in ages from 11 to 36 years. Shortening had been due to poliomyelitis, arrested growth secondary to osteomyelitis of femur and tuberculosis of the knee.

When the required increase in length has been obtained several turns of plaster bandage are applied over the turnbuckles to prevent meddling. The patient is observed several days and then discharged to go to his own or a convalescent home, with instructions to keep the limb elevated until the time for readmission to the hospital in two months for removal of the apparatus.

Under gas oxygen anesthesia the plaster is cut anteriorly and posteriorly. One half is removed carefully. The protruding pins are scraped free of all plaster, carbolized with 95 per cent and washed with alcohol to remove the phenol. The remainder of the plaster with the pins is then removed.

A snugly fitting circular plaster is applied, including the knee joint and moulded about the tibial condyles. If x-rays confirm union the patient is permitted to bear weight. Plaster is discontinued only when x-rays show good bone structure at the site of lengthening.

SUMMARY

Leg lengthening operation is more physiologic than leg shortening in same type of case.

The new plastic osteotomy described has shortened the convalescence period by several months. Increase in length of not more than $1\frac{1}{32}$ inch twice a day with the leg lengthening apparatus described has not resulted in any morbidity or mortality. The average total increase has been $2\frac{3}{4}$ inches in patients varying in age from 11 to 36 years.

PRIMARY shock is essentially neurogenic and is due to an overstimulation of nervous paths by either psychical or traumatic (mechanical, thermal, chemical) influences.

THE TREATMENT OF ULCER OF THE LEG*

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"IT is easy to get a leg ulcer to heal. It is hard to obtain a kind of healing that will last" (Leriche, Fontaine and Maitre[1]). With this statement, which I take the liberty of translating, these authors open a recent article. I feel that it is so apt that I begin the present discussion with it also. I agree with them in feeling that with the older methods of treating ulcers recurrence is the rule. Yet on the basis of our findings, I have the conviction that with the majority of leg ulcers treated conservatively and almost all of those in which radical excision and proper grafting are employed, permanent cure will result.

The importance of cleanliness and protection to the healed ulcer area and of immediate return to the out-patient department, should injury or spontaneous infection occur, has been emphasized to the patients in our series at discharge from the clinic. After healing, if elastic adhesive has been employed, the application of the bandage is made one more time and a dry elastic cloth bandage is then substituted. If it is thought desirable, this is left on continuously for support. Through these measures recurrence has been limited largely to those cases in which injury is the principal cause.

We readily recognize the fact that with older methods of treatment a type of healing is usually obtained which results in unstable conditions at the site. The epithelial layer is thin and usually devoid of hair, sebaceous and sweat glands and papillae over an extensive area. Methods, whether conservative or radical, should aim at producing better circulatory conditions of the extremity as a whole and a thicker, healthier and therefore more durable skin layer. Often this is impossible due to the tremendous amount of scar which has been deposited in the zone around the periphery and under the base of the ulcer.

GENERAL CONSIDERATIONS

According to almost all authors, the incidence of varicose ulcer is on the increase. This fact is probably due to modern living conditions, including long hours of standing still or sitting down. Referring to England, A. Dickson Wright[2] recently said, "No one realizes what a terrible curse varicose ulcer is to the lower classes of this country; it is much more prevalent than is imagined, because most of the sufferers, tired of receiving no relief from the medical profession, settle down to endure their complaint with occasional extravagances in the form of quack remedies. In every large town of the midlands may be found an institution, under the supervision of unqualified people, for the treatment of 'bad legs.'"

Such is the picture of this country also in many localities. The unhappiness and economic loss in these cases is very regrettable, the more so because almost invariably the ulcers will respond to the proper treatment. In other words, they are curable.

In five articles[3,4,5,6,7] between 1929 and 1936 I have endeavored to point out the modern advances of treatment and to stress the great curability of ulcer of the leg. In this briefer article, it will be my purpose again to refer to and re-emphasize some of these points, to add recent developments and to apply certain pertinent facts concerning the general problem of wound healing to this particular field. As great as the advancements have been, there are already indications of still more changes.

Definition. Ulcer of the leg is to be considered as a special type of wound found in a special location. In general terms, an ulcer may be defined as an open wound due to the loss of skin or of skin and subcutaneous tissue through trauma, infection, new growth, circulatory deficiency, or a combination of two or more of these factors. The term ulcer implies that the wound is relatively wide transversely in proportion to its depth—too wide to heal per primam.

The following chief causes of ulceration of the leg are recognized:

1. *Trauma:* injury in the form of mechanical force, extremes of temperature, heat and cold, concentrated chemicals, Roentgen ray or radium.

2. *Infection:* syphilis, tuberculosis, amebiasis cutis, carbuncle, malignant pustule.

3. *Neoplastic growth:* rodent ulcer, Marjolin's ulcer.

4. *Circulatory disease:* varicose veins, limited gangrene of arteriosclerosis, scorbutic ulcers, mal perforant, bed sores. The circulatory changes may be primary or secondary to trophic changes as for example after division of a nerve.

5. *Combinations of the preceding four causes:* Examples are syphilis supervening in a varicose vein case, Marjolin's ulcer in which a squamous cell epithelioma forms in the chronic ulcer from a burn, bedsores in which mechanical trauma (friction), circulatory stasis (pressure) and infection all play a part.

This list is by no means a full one, but at least will serve to show the multiplicity of causes to which ulcer may be attributed. Such terms as "luetic," "varicose," "epitheliomatous" should properly be reserved for those cases where the etiology is definitely proved. Leriche rightly condemns the indiscriminate use of the term "varicose ulcer" in all cases in which varicose veins are seen somewhere on the ulcerated leg.

The various forms which ulcers assume when due to various diseases are well illustrated in Boyd's "Pathology."[8]

LOCATION OF ULCERS

Leriche et al.[1] point out the fact, which I have frequently had occasion to verify, that varicose ulcer is most commonly found along the internal surface of the leg over or above the internal malleolus where the skin is stretched over the bone as if upon a saddle. A typical ulcer due primarily to varicose veins is shown in Figure 1. Friction or other injury from a shoe has led the British to call these ulcers "boot ulcers" or "stocking ulcers." The factor of scratching with the fingers because of a chronic itching of course also plays its part. Varicose ulcer usually starts as a single lesion.

Syphilitic ulcers are usually multiple unless the lesion is due to gumma formation. They are generally located in some part of the upper two thirds of the leg. I have seen as many as forty ulcers from this cause present on a single extremity. (Fig. 2.) The persistent multiple ulcerations due to infection by staphylococcus aureus in those ulcers due to trauma have no special site of predilection depending as they do upon purely casual factors. This condition is known as ecthyma. It is similar to impetigo, but is more chronic in nature and not so contagious nor infectious. Strangely enough, Goodman[9] finds that most varicose ulcers are located on the left rather than the right leg. He found that far more of the patients with ulcer on the right leg had positive Wassermann tests than those with ulcers on the left leg.

In our series[4] at Vanderbilt Hospital the incidence of leg ulcer is about three-fifths as great as that of acute appendicitis.

ETIOLOGY

Commoner Causes. A study of the literature shows that opinions are at variance concerning the proportional incidence of ulcer of the various types.

Varicose veins must still be considered by far the commonest cause of leg ulcer. Various estimates are given; in many of them this condition is estimated as causing

Fig. 1. Varicose veins with ulceration of leg in a man of seventy years. A, before operation. Dilated vein indicated by arrow. B, successful sieve graft in ankle region. (Note that perforations have already almost entirely epithelialized.) C, healed result fifty-seven days after operation, with small deep graft at top. (From Douglas, in *South. M. J.*, 24: 5, 1931.)

Fig. 2. Multiple bilateral luetic ulcers. A, before treatment. B, healed condition following antiluetic treatment and local use of elastic adhesive.

as high as 90 per cent of leg ulcers. The percentage would probably be cut down greatly if Wassermanns were drawn on every patient. In Goodman's series of sixty-four cases, syphilis was proved to exist in thirteen. This does not indicate, however, that syphilis was the cause of ulcer in each case. As the present national fight against syphilis proceeds, it seems obvious that the proportion of ulcer due to other causes will increase.

In a recent article, Leriche and his associates[1] logically ask the question as to what conditions should be included under the term "ulcère variqueux" or varicose ulcer. After recounting the histories of two cases in which they performed a total removal of the internal saphenous vein for large ulcer of the leg, they state that in both cases healing of the ulcer was accomplished but the ulcers recurred without any return of the varices. They are right in proposing that the term "varicose ulcer" be reserved for those ulcers which develop on a limb showing varicose veins and through the tissues of which varicose veins extend. Stagnation with the chemical changes in the tissues accompanying it should be demonstrated before the term "varicose ulcer" should be used.

Trauma from burns or other causes is another common cause of leg ulcer. In sixty-six cases of ulcer which came to them for surgical treatment, Brown et al.[11] found burns of the leg the commonest cause and osteomyelitis next. Other causes of lower incidence included varicose veins, radium, x-ray and other trauma, osteomyelitis, phlebitis, hemolytic streptococcus gangrene of the skin, and syphilis. De Takats and Curtis feel that hereditary factors and familial predisposition are important in leg ulcers.

Rarer Causes. Among the less common causes of leg ulcer in our series may be mentioned those due to malignant degeneration of a scar, to radiodermatitis, Marjolin's ulcer, also rodent ulcer and elephantiasis. The filarial form of the latter is common in the tropics.

Hemolytic streptococcus gangrene of the skin described by Meleney[12] is another rarer cause of ulcer of the extremities, as is a diphtheroid organism closely related to the Klebs-Loeffler bacillus.[13]

Many other of the rarer causes of ulceration are summarized in a recent report by White,[14] who calls attention also to epidermophytosis (ringworm) of the foot with secondary ulceration of the leg, nodular ulcerative syphilis (tertiary lues), erythema induratum with multiple ulcers (which he feels is due to tuberculosis) also to the extragenital venereal ulceration which can occur on the extremities, such as chancroid, granuloma inguinale and lymphogranulomatosis of Nicolas-Farre. He aptly mentions factitial or self inflicted ulcers, and those due to localized allergy, injury from industrial pursuits such as those due to chrome lime, fumes of hydrochloric acid, hydrofluoric acid and shale oil. He also mentions sickle-cell anemia, typhoid encephalitis, and multiple sclerosis as a few general conditions which may cause ulcers.

We have had occasion to treat ulceration of the leg from overdoses of bromides in a child. This drug, like the iodides, may cause ulcers which have a vegetative appearance.

While this list is not complete nor exhaustive by any means, one may obtain from it an idea of how often leg ulcer is a primary condition and how often the complication of other disease.

Every effort should be made to find the specific cause of ulceration if such be present, since definite treatment may then be instituted which will result in rapid cure. The local appearance may be helpful but rarely reveals the etiology. Much may be determined, however, by a study of the ulcer edge. Luetic ulcers are usually punched out and crater-like. Tuberculous ulcers frequently have overhanging edges. Epitheliomatous ulcers show a hard thickened epithelial edge. For the reasons given above (Leriche) one should not consider the mere presence of varicose veins as being diagnostic of varicose ulcer but should insist that insufficiency of the venous

circulation be demonstrated at the site both by circulatory and laboratory studies. Many patients with varicose veins develop ulcers only after they have contracted syphilis.

LOCAL PATHOLOGY

The local tissue reaction which results in loss of substance to variable depths will depend upon the nature of the specific cause. In all, prevention of further complications will greatly enhance the rate of healing and shorten the healing time. Individualization will lead to specific therapy both as to infection and to veins. Ochsner and Garside[15] point out the following local tissue changes in varicose ulcers: stagnation and anoxemia with increase in water content and corresponding decrease in oxygen content, an increase in local N.P.N. and acid bodies and decrease in arterial supply. All of these deleterious changes lay the part open to complications resulting from minor trauma or infection. Douglas[4] has suggested the following form of outline for the usual clinical course of certain types of ulcers when inadequately treated:

"1. *Origin and Course of Varicose Ulcer.* Varicose veins (with or without phlebitis), passive congestion, edema, minor injury causing ulceration, secondary infection, cicatrization of edge and base, causing further impairment of circulation. Result, unstable healing or extension of the ulcer.

"2. *Origin and Course of Syphilitic Leg Ulcer.* Luetic obliterative endarteritis of capillaries, stasis, ulceration. Result, if treated, early healing with atrophic scar. Result, if improperly treated, secondary infection, cicatricial change, chronic ulceration.

"3. *Origin and Course of Leg Ulcer Following Lymphatic Stasis.* Superficial infection, acute lymphangitis, chronic lymphangitis with lymphatic stasis, brawny induration with local circulatory deficiency, minor injury, ulceration, cicatricial change, chronic ulceration.

"4. *Origin and Course of Ulcer Following Trauma.* Burn or other trauma, infection, healing by cicatrix (contractures if over joints), local impairment of circulation, injury, chronic ulceration with or without malignant change.

"It is interesting that practically all of the leg ulcers which come to us for treatment will fall according to their causes into one of these four groups. Likewise, one by using it may easily classify each according to its particular clinical course of development or regression.

"One fact stands out from it. This is the large rôle that local circulatory changes play in causing an ulcer to become chronic or intractable to treatment. In the case of most ulcers the vicious circle of vascular deficiency, ulceration, healing by scar tissue with still greater vascular deficiency, is repeated over and over again with frequent insults from trauma and infection, to make a cure without radical operation more and more hopeless."

Only at the beginning may ulcers be considered to be due to one cause. At first there may be a primary cause of ulceration and if this is removed or even attenuated there may result a rapid cure, but the primary cause as a rule very soon becomes mixed with other factors. Legs which certainly from the condition of the veins should be ulcerated often escape this unfortunate occurrence because of the careful and cleanly habits of some individuals while in others who subject themselves to injury through force or scratching a relatively slight degree of varicosity may mean a sentence to early and long continued ulceration.

SYMPTOMS

In acute ulceration on the leg from any cause the symptoms are those of acute infection. In chronic ulcers pain and other symptoms are practically absent if infection and edema are controlled. One does, however, find pain in two conditions. The first is associated with Marjolin's ulcer or

malignant squamous cell degeneration of an old ulcer site, usually from a burn.

The second condition is that of erethistic or painful ulcer. This consists of a chronic, very painful ulcer at the ankle joint. The pain is usually more severe at night than during the day and may best be treated by running a probe lightly over the entire surface of the ulcer in order to find one or more spots which will be indicated as the chief cause of pain. The sensitive nerve filament is then cocainized and touched with full strength carbolic acid.

TREATMENT

General Principles. In a previous article[3] I stated two principles which if faithfully followed will result in the cure of almost all so-called intractable or chronic ulcers. At present after several years I am even more certain of their fundamental importance. Experimental and clinical evidence at Vanderbilt and elsewhere have reinforced the soundness of both. Briefly they are:

1. Carefully determine the cause or causes of ulceration and treat each.

2. Substitute good for unhealthy tissue by getting rid of infection and by encouraging healing either through protective measures or by grafting with the addition of protective measures.

The extremities and more particularly the lower extremities have two rather unique etiologic factors which are of great significance and which must be understood to make any treatment rational.

The first is that, the legs being dependent, there may be present various degrees of impairment of the venous return, resulting in stagnation and deficient metabolism in the skin and subcutaneous tissue, local anoxemia and acidosis, with a decrease also in arterial supply. In addition to this, there are edema and lymph stasis which frequently result in a still further impairment of the blood circulation.

The second unique factor is that the skin over the tibia and, we may add, over the malleoli is stretched, as recently pointed out by Leriche, as upon a saddle, so that in addition to being in poor circulatory condition it is particularly subject to trauma such as that from rubbing of shoes, blows against objects, etc. To this the dirt of the street on socks is commonly scratched and rubbed in by fingers. Thus the "stage is all set" for ulceration.

On the other hand, bad as these vicious circular factors may appear, it must be admitted that there are two factors anatomically and functionally peculiar to the extremity which aid tremendously in the treatment of ulceration.

First, unlike that of most organs, the circulation of the lower extremity, be it arterial, venous or lymphatic, may be modified with ease (periarterial sympathectomy, excision of varices, "pavaex," anastomosis of superficial to deep lymphatics [Kondoleon]).

Second, the limb as a whole may be treated (bandaging with elastic adhesive, occlusive plaster cast [Orr treatment for osteomyelitis], transparent rubber or composition jackets).[33,34]

Technique of Treatment. Treatment of underlying causes of ulceration is a primary principle to be strictly adhered to. Varicose veins may be treated either before or after the ulcer is healed through local measures. Should elastic adhesive be used to strap the ulcer, injection of veins may be performed while the leg is being supported and the ulcer covered by the bandage. Details of varicose vein treatment will be omitted here because of space requirements.

As will be shown, the general condition of the patient has an important bearing on the healing of ulcers and should be determined by a thorough physical and laboratory examination. A balanced diet with the necessary vitamins will combat anemia and vitamin deficiency and hasten the healing process.

If a specific causative organism is indicated by intensive study, treatment should be aimed at it. Syphilis should be as intensively treated. Granuloma inguinale and tuberculosis will need appro-

priate general treatment as well as intensive local measures. Elephantiasis should be treated by anastomosis of the superficial and deep lymphatics according to the method of Kondoleon or some modification of it.

In chronic osteomyelitis, dead bone must be removed and granulation tissue allowed to form before strapping or grafting. A reasonable degree of periostitis underneath the ulcer base is to be expected as a usual bony reaction. It will rarely need attention. In hemolytic streptococcus gangrene of the skin, Meleney[12] advocates wide incision to drain pockets "as far as subcutaneous necrosis extends but no farther." Brevity forbids the mention of many other general measures.

GENERAL FACTORS AFFECTING HEALING OF ULCERS

Since ulcers are all wounds of a particular configuration, a knowledge of general factors which may hasten or retard healing will prove very important in their treatment. This is a field in which, although much research has been undertaken, little has proved conclusive or final. Some of the factors which certainly affect healing are age, diet, distant infection and hormones.

The facts concerning these and many other factors have been finely summarized by Arey[16] and Anderson[17] in recent articles. Carrel, Du Nouy and later Howes and Harvey have shown that the rate of healing is inversely proportional to the age of the patient. The latter authors have shown that this is due to the earlier onset of fibroplasia. These authors and others agree on the opinion that a high protein diet favors healing by shortening the total time required for wound repair. Conversely, Ravdin and Thompson[18] experimentally demonstrated that hypoproteinemia results in retardation of healing in dogs. Carbohydrate metabolism does not seem to be so important except as it assumes disease proportions as, for instance, in diabetes. Vitamin A and C deficiency are important in wound healing. Arey recounts

the experiments of several authors, especially Saitta,[19] in supporting his belief that a vitamin A deficiency which has existed for a long time delays wound repair. According to this latter author and Anderson, treatment with vitamin A, even though only locally, accelerates repair. This was later confirmed by Taffel and Harvey. In general it may be said that the effect of diet on wounds has not yet been put on a satisfactory clinical basis. Much careful work is yet needed.

Lanman and Ingalls,[20] through experimental studies, showed that partially scorbutic animals have lowered tensile strength in wounds and that asymptomatic scurvy is of importance in causing a delay of healing in humans. Horn and Sandor,[21] in 1934, showed the favorable influence of salves and oils containing vitamin A applied directly to human traumatic wounds. As stated by them, both epithelization and granulation formation were speeded and through the more rapid growth of the latter, secondary infections were restrained.

Often patients with leg ulcer are suffering from infection elsewhere. For example, syphilis may exist in a patient with a varicose ulcer. Carrel has shown that distant infection, experimentally produced, retards healing.

The effect of ulcers on the body as a whole is usually negligible except in severe cases where infection causes certain changes in metabolism, including a higher basal rate during the destructive phase (Schneider and Straaten[22]). Dickson Wright has shown that leg ulcers cause a mental change in patients which is even reflected in their countenances. Their sad expression he terms the "ulcer facies." In the past this has been due to the little hope of cure which standard leg ulcer treatment afforded. With modern methods of therapy, cure is the rule, and the mental outlook of the patient need no longer be forlorn, but should be and usually is one of optimism.

The first consideration, then, will be found in discovering the cause of ulceration.

It is certain that *secondary anemia* should be treated by diet, iron tonics, and if necessary, blood transfusions. Likewise endemic or nutritional edema, a fairly common condition, should be treated by a diet high in calories and in proteins. This edema, regarded by Youmans[23] as of little importance except "as an indication of a more fundamental disorder," most commonly involves the lower extremities and may aggravate any ulceration present. Its importance as a cause of slow healing is found in the fact that diet too low in proteins may retard healing of ulcers.

The work which has been done in periarterial sympathectomy indicates that an increase in the circulation of the whole blood to a part will result in a more rapid healing. From findings in Raynaud's disease, one concludes that the opposite is true in the case of decreased arterial supply. The purpose of inflammation with its increased blood flow to a part up to a certain point is to speed up the healing process.

The conditions for fulfilling the second basic principle will be found by studying the fundamentals of the mechanism of closure and in making healing the more rapid by providing conditions worked out along these lines. Arey[16] holds that "the chief biological factor responsible for the extension of epithelium over the denuded area is the ameboid movement of the neighboring cells themselves." He feels that the mitosis and cell proliferation have gradually lost advocacy in the face of careful studies. From corneal studies with Covode he states that there is found an actual decline in mitotic frequency during the first days following an injury.

Studies by Loeb, Arey, Marchand and Werner[24] all show the movement of epithelium over mammalian wound surfaces and conclude that "this must be the result of an active wandering since mitoses were not increased during the early stages and especially did they not occur in the border zone." Arey states that "in view of all the available information the primacy of cell migration in the epithelization of wounds cannot be doubted, even though the contraction advocated by Carrel (1910) and Burrows (1924) may lessen the diameter of the original lesion markedly in some locations." He concludes that two factors are of importance in the rapid restoration of epithelial continuity: (1) contraction, important in mobile skin which is loosely attached to the deeper structures, and in which it can and does affect both epidermis and corium as a unit; and (2) cell movement apparently by amebism, mitosis for the most part coming later after epithelization is complete.

It is to be noted that all opinions embrace the importance of epithelization in the zone surrounding the wound and of contraction in reducing the size of the wound so that epithelization may complete the work of contraction and so of healing. Arey, in speaking of the healing attained through scab formation, states that the extension of epithelium from all sides is in progress even on the first day. "The granular and horny layers of the nearby epidermis disappear and resolve into a homogeneous syncytial layer of characteristic rod-like form." This covering sheet Loeb has designated as "the upper protoplasmic layer." It migrates fastest of all the epithelial components and rapidly makes a covering to the whole scab; even at thirty-six hours this process is well along to completion.

He makes a statement which we consider very important to our work from the standpoint of both conservative and radical treatment: "If the lesion be small enough and the supply of cells large enough, the mitotic phase may never become detectable as such. In wounds so large that the adjoining epithelium cannot supply sufficient cells within a comparatively short time cellular proliferation then enters before epithelization is complete and cell movement and proliferation go on simultaneously."

If we apply these facts to our studies on the healing of hollow rings of skin of flattened doughnut shape, applied to a granu-

lation tissue of a dog, we will realize that they are pertinent to the present discussion of healing.[7] Invariably the central circular

or of pseudopodia except in a direction inward. It is likely that the cause of this difficulty of centrifugal spread is that like

HEALING OF RING OF SKIN ON A GRANULATING SURFACE
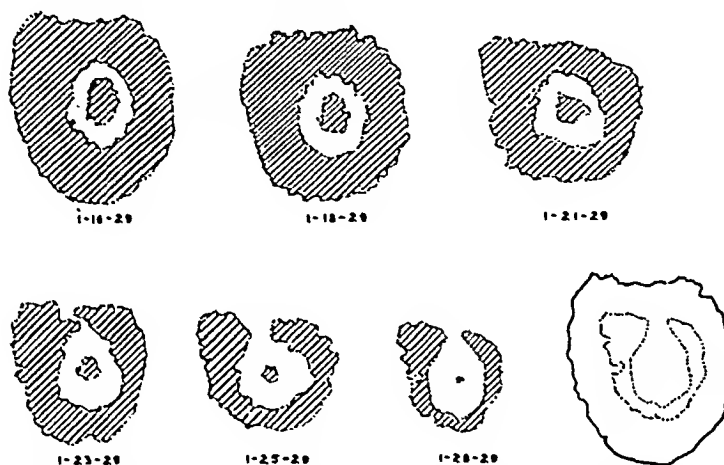
FIG. 3. Greater rapidity of centripetal healing than of centrifugal healing. Size of outer edge of ring of skin has remained same while inner edge of ring has completely healed. (Tracings on cellophane.)
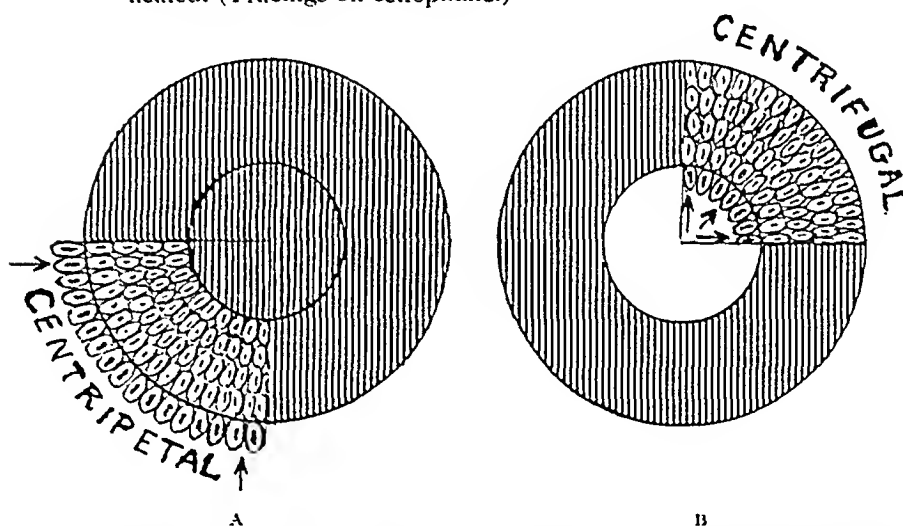
FIG. 4. Diagrammatic representation of centripetal and centrifugal healing. A, centripetal healing. The numerous epithelial cells at the edge of a granulating wound are extending inward toward the center to cover the quadrant. Here seventeen cells must account for covering the space of fifty-four. B, centrifugal healing, representing a "pinch" graft on a granulating surface. A few cells at the edge of the graft must extend outward and connect up with the next line of cells in order to accomplish healing. Here seven cells must account for covering the space ordinarily covered by fifty-four. This is the slower and less sure process of healing. In this diagram the factor of contraction is not taken into account. It is assumed that the skin graft at the center is too far from the periphery of the wound for the latter to grow in to it.

areas heal completely (mainly due to contraction) long before epithelization has begun to proceed outward from the outer border of the graft. (Fig. 3.) Apparently the spread of the synctial membrane is difficult by the mechanism of cell migration

the spokes of a wheel the pseudopodia-like process would become further and further apart as their spread proceeded peripheralward. The membrane formed by them will, therefore, not remain intact unless processes also spread at right angles or tangen-

tially to the radial lines and joined up opposite portions of the outgrowing processes. It is not hard to conceive that this
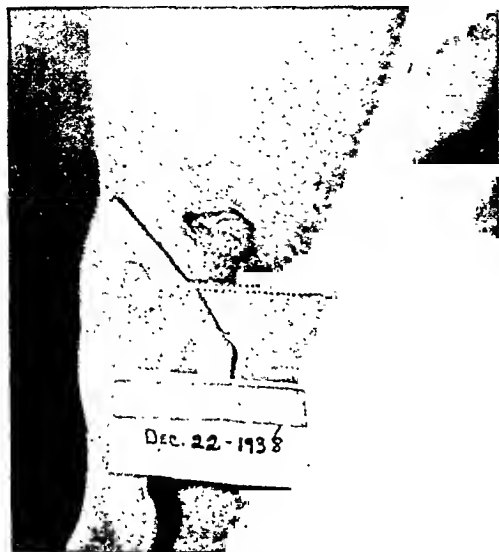
FIG. 5. Small healed recurrent postphlebitic ulcer treated by circular strapping with elastic adhesive. Note ulcer area covered with several layers of epithelium, cells of which have desquamated and stuck to plaster. This is the final stage of healing when mitosis is active in the epithelial layer which has spread over the wound.

process of spread of cells in a membrane in an outward direction would be much more difficult to accomplish than a spread inward or centripetally, in which cell migration or pseudopodial processes would automatically cause cells to be placed more and more in contact with each other as they reached nearer and nearer toward the center. When, however, a nearby edge of growing epithelium is present, then a joining up of the two edges is probably effected by surface tension or by positive chemotaxis which may cause the two edges to draw or flow together and finally to form one membrane.[24a]

This explanation is readily seen also to be borne out clinically in the case of sieve grafts. In the case of this type of graft, small island areas of intact skin are punched out at the donor site and left behind as an integral part of the thigh or other part of the body as the full or whole thickness graft of the skin is lifted. The latter, a sheet of skin perforated with holes

like a "sieve" is then sewed into the ulcer defect. One might suppose that the edges of the islands of the donor site being undisturbed skin (an integral part of the body), would grow out very rapidly and that the rate of healing of the islands would be far more rapid than that of the holes of the completely lifted or transplanted skin. Interestingly enough, this is not true. The perforations in the graft are usually found to be healed at a time when the epithelium of the island edges has only spread out about 2 to 3 mm. Unless the islands are placed quite close, which would enable epithelium to grow virtually inward or toward the next island, instead of outward for an extensive distance, healing, while it will occur, will require about double the time of healing of the perforations. Since conditions are otherwise nearly ideal at the donor site (good tissue, no infection) and often anything but ideal at the recipient area (transplanted tissue, scar tissue and infection often present) we conclude that the main difference is that in the case of the donor site we have difficult conditions mechanically for healing to take place, viz., islands far apart with edges of limited size, centrifugal migration of cells or pseudopodia formation or (later) proliferation by mitosis, while in the case of the perforations in the graft edges which are large with a small area to cover, mechanical conditions are better from the cellular standpoint. Here the healing is centripetal from the start. Cell migration or pseudopodia formation and later proliferation by cell mitosis are all carried out under ideal conditions. Figure 4 is diagrammatic but it gives an idea of the differences between centrifugal and centripetal spread of epithelium in healing. The effect of mitosis in the final stage of healing is shown in Figure 5.

We have reached the same conclusion from close observation of small deep or "pinch" grafts. The epithelial edge of skin surrounding a granulating wound which has been covered with these grafts will grow or migrate centripetally or inward at a

rate so far surpassing in velocity that of the edge of the outer grafts that we have found that it is purposeless to place the latter closer than 1 cm. from this edge. On the other hand, the grafts must be placed close, viz., ½ to ¾ of a centimeter apart at most, or the healing of the wound will proceed extremely slowly. In the latter case the migration of cells or growth—in other words the healing—is centrifugal until the epithelium reaches another graft. At this time the real beginning of centripetal healing will be attained by the formation of circles between any three or four grafts. (Fig. 1B.) Should the grafts be placed free at distances apart of 1 to 2 cm., the slow centrifugal phase of healing will consume a time which will greatly prolong healing and even make it impossible. It must be borne in mind that in all cases contraction will play a greater or less rôle in reducing the distances between the grafts and between them and the epithelium of the wound edge.

APPLICATION OF KNOWN FACTS CONCERNING WOUND HEALING TO TREATMENT

If we are to apply our knowledge of epithelial healing in wounds to leg ulcers, several indications at once seem to stand out. First, since epithelial cells must flow or migrate as well as proliferate to cover a granulating wound in healing, it follows that the epithelium of the edge must be at least reasonably healthy and strong in order to accomplish healing. If the edge is too thin or is badly infected or irritated, we should expect little in the way of healing. In our practice we find that an epithelial edge at the periphery of an ulcer may look very bad yet proceed to spread. In such cases the type of healing is weak and recurrence is the rule. In those cases in which skin has lost some of its normal components (for example, sweat and sebaceous glands and hair follicles), its strength is weakened, it is "unhealthy" skin. In reality it is scarred skin and is subject to various irritations and infections.

Brown, Byars and Blair[11] have illustrated this with three photomicrographs of the edges of leg ulcers. The first shows the edge of a varicose ulcer open most of the time for twenty years. One sees "practically no epithelial activity either in filing up keratin or attempting deep invasion." In the second, which is one of scar epithelium adjacent to an ulcer, one sees "thin flat epithelium without hair, glands or papillae" but with a heavy keratin layer indicating marked cellular activity as a response to wound stimulus. The next photomicrograph shows how scar epithelium, in contradistinction to the normal, may easily be lifted off its base by trauma or hemorrhage, thus causing re-ulceration. In similar photomicrographs of excised tissue forming ulcers, we have shown how the number of normal skin structures (hair follicles, sweat and sebaceous glands, etc.) becomes less as one approaches the actual epithelial edge of the ulcer. I exhibited these at the Southern Medical Association meeting in 1930 in order to emphasize the necessity for radical, wide and deep excision of scar in selected cases.

In order to obtain healing with strong and healthy skin, of course the ideal would be radical treatment by excision and grafting. Excluding this as unnecessary except in advanced cases, the indications are (a) to combat infection in the ulcer and surrounding skin edge and prevent secondary infection; (b) to provide against further injury to the base and edge of ulcer; (c) to avoid exuberant granulation and excessive scar tissue formation; (d) to favor contraction of edges, and (e) to favor healthy epithelization. These points may be regarded as closely related indications mutually interdependent. Applied together to ulcer treatment, they mean "steady and stable healing."

While they are closely related, ulcers differ greatly in requirements. Thus in one ulcer infection may predominate, in another frequent injury may play an important rôle, etc. We shall, therefore, consider them separately.

(a) *Treatment of Infection.* We have already called attention to the importance of diet and other general measures in healing and consequently in overcoming infection. The establishment of infection should be prevented if possible as soon as an accident occurs by thorough shaving of the wound edges followed by their sterilization and cleansing with ether. Large abrasions which may lead to ulceration may then be strapped with elastic adhesive. We have obtained rapid proliferation or migration of epithelium by this method if the wound is shallow and relatively clean.

There are many methods of treating ulcers after infection is established in them. The chief point to keep in mind is to honestly individualize each case in order to determine if possible the specific organism responsible for the infection. In streptococcus hemolyticus gangrene of the skin, cultures will reveal the organism. Its treatment has already been described.[12] Ulcer due to diphtheroid bacilli will readily respond to treatment (Barber et al.[13]) with autogenous vaccine and local application of permyase jelly.

Diphtheria. In a recent communication Melchior[13a] states that the appearance of granulations with Klebs-Loeffler bacillus infection was deceptive with small whitish spots sometimes minute, more often a dirty unhealthy aspect with markedly delayed healing. The granulations formed an almost smooth surface and were violet colored, in places grayish or yellow, edges atonic. He found the only treatment efficacious in eight to fifteen days was powdered methylene. Graham reports that he has had two cases of empyema with the same infection. I have seen two diphtheritic ulcers of the extremity which cleared up with local and general administration of antitoxin.

Ulcers due to micro-aerophilic hemolytic streptococcus infections are to be treated by wide excision and the application of a suspension of zinc peroxide in water as a paste to all parts of the wounds, especially pockets sealing the wounds, laying fine meshed gauze washed in the suspension over the ulcer surface and finally sealing this in with fine meshed gauze impregnated with zinc oxide ointment.[13b] Infections due to other anaerobes may be treated in the same way.

In secondary ulceration of the leg following ringworm of the foot, primary attention should be focussed upon treating the epidermophyton infection. The troublesome infection of ulcers from B. pyocyaneus may be controlled, according to Brown et al.,[11] "by frequent painting with strong solutions of the dyes (gentian violet and methylene blue) or by proprietary mercurials plus the copious use of soap and water." They feel that acetic acid and hydrogen peroxide are of little value in such infections.

When none of the above organisms can be demonstrated, but only the usual pyogenic ones, any one of a number of antiseptics may be tried. These, however, in our experience should rarely be considered as curative, except in the case of small ulcers, for after infection is reasonably taken care of the problem of epithelization remains. Rather they should be regarded as preparatory for further conservative or radical measures.

Boric Acid Packs. In most of the large ulcers which we see for the first time, after shaving and cleansing with soap and water we apply sterile dressings covered with a layer of cellophane and gauze bandage over all. Carrel tubes are incorporated in this between the skin and the gauze. Irrigations are then done at four hour intervals with saturated solution of boracic acid while the patient is awake. A warm water bottle at about 105° F. is kept over the ulcer site for as long at a time as convenient. The Carrel tubes may be omitted and moistening of the dressing done with a medicine dropper or syringe through one or more small holes cut in the cellophane.

Normal saline may be substituted for the boric. Grossly, ulcers and surrounding tissues have cleaned up rapidly under this routine. In still dirtier and more malodorous cases the Carrel-Dakin technique

is carried out. Especially is this routine followed if operation is contemplated. Azochloramide preparations or other antiseptics which aid in dissolving necrotic tissue may be substituted if desired.

A single cautious application of 95 per cent phenol to a dirty, necrotic, granulating ulcer base, followed almost immediately by alcohol, will often clean up the necrotic base so much that it will appear red at the next visit. Care must be taken not to spill the carbolic on the skin.

Anderson,[17] in a very recent quantitative study, has shown that the few antiseptics which decreased the number of surface organisms in wound healing at a normal rate, were ineffective in the presence of tissue necrosis and exerted no beneficial effect on the rate of wound repair. He found, however, no contraindication to the use of usual antiseptics since no evidence was obtained to show that their chemical action on wound tissue cells was excessive.

Evidence has recently been presented[7] to show that Dakin's solution of hypochlorite, while antiseptic, may be mildly toxic and slightly retard healing.

Gentian violet was first advocated for the treatment of joint infections, then later for burns by Firor and Aldrich. I have used it with good results to provide an antiseptic membrane in burns, where a 1 per cent aqueous solution was employed. A series of three articles has appeared in the *New England Journal of Medicine*, advocating its use for ulcers of the leg.[26] In the latest of these, a preliminary report, Thurmon and Chaimon advise the use of 2 per cent aqueous solution. It is applied three times a day for two to three days when a hard crust would have formed. The crust is dried in the air and no bandage applied. Patients were kept ambulatory and crusts renewed only if loose. They describe fifteen ulcers treated by this method in which healing was very prompt and scarring minimal.

Maggot Therapy. We shall mention only in passing the large volume of work which has been done by Baer[27] and many others on the sterilization of wounds, especially osteomyelitis wounds, with sterile maggots. In its place it gives excellent results, but since it requires a special set up for its use and does not allow ambulatory treatment, it is of little value in leg ulcers.

Cod Liver Oil Therapy. The beneficial effects of cod liver oil in chronic ulcers have been described and the literature summarized by Epstein[28] in a series of cases 31 in number. In part of them he used the oil with equal parts of anhydrous lanolin and in the other the anhydrous lanolin alone. There was a very small difference in the two series in favor of the cod liver oil preparation. The action of cod liver oil and other such preparations is thought to be due to its vitamin content. To vitamin D is attributed mainly the stimulation of epithelial proliferation, to D and A together the rendering of bacteria in wounds non-toxic and the stimulation of the healing process. Epstein feels, and we agree, that "cod liver oil alone does not constitute sufficient treatment," and that it should not supplant therapy aimed at basic etiologic factors.

Cod Liver Oil and Allantoin Therapy. Recently Salzman and Goldstein[29] have described the treatment of a few cases of chronic ulceration with the daily application of a combination of cod liver oil and allantoin extracted from maggots, which they term codalltoin. The two are combined in proportions of 45 per cent cod liver oil and 2 per cent allantoin with phenol 0.5 per cent and prepared in a lanolin base. Allantoin is so-called because it is a characteristic component of the fetal allantoic secretion. While their results appear to be convincing and very promising, one is left to wonder in a compound preparation how much of the effect is due to the weak phenol. They warn against using phenol in large ulcers on account of the danger of absorption of too much of it. So often the presence of live maggots is a source of discomfort and embarrassment

to the patient that we agree with these writers in feeling that if allantoin is the substance largely responsible for their beneficial effects, it should be used in their place. This also permits the treatment to be ambulatory.

(b) *Provision against Further Injury to Ulcer.* It has long been our belief that ulcers and other wounds should be regarded as *fractures of the skin* and likened to fractures of bones. If the same principles of rest, protection and later massage and gradual leaving off of pressure and graded resumption of the standing posture as emphasized by Owens[10] be carried out, healing, other factors being equal, will be more rapid and stable. This latter procedure will pay dividends especially in the case of healing over the knee or ankle joints and particularly in the case of skin grafts. No surgeon would think of treating a fracture of a bone without splinting and putting the fragments at rest to accomplish union, yet ulcers are often treated by methods which favor further injury by blows, drying, rubbing of gauze on epithelial edges, sticking of gauze to granulations and secondary infection. The Orr treatment of osteomyelitis[30] by drainage and rest in a cast alone emphasizes these points.

(c) *Avoidance of Exuberant Granulations and Scarring.* If sterility can be rapidly attained, granulations will not grow exuberantly to form "proud flesh." In general, the formation of a membrane, as in the gentian violet or tannic acid treatment, also will prevent this from occurring. In case exuberant granulations occur, strapping with elastic adhesive (described below) will flatten them down to the level of the epithelium in a few dressings. They may also be cauterized with silver nitrate stick, a procedure which we feel should be rarely practiced since the better methods described are available. Since the flattening down of granulations to the epithelial level of the ulcer edge enables the latter to grow more smoothly, an ulcer allowed to heal under the elastic adhesive will have less tendency to scarring and keloid formation.

The exception to this is found in very dirty ulcers. Here more scar will form if the secretions are held in. Proper drainage must be afforded in these by fenestration of the elastic adhesive. (Fig. 10.)

(d) *Stimulation of Normal Contraction.* Carrel, Dehelly, Depage, Du Nouy, and others have shown the importance of contraction of the ulcer edges during cicatrization as a factor which reduces the size of wound to be covered with epithelium. According to Arey, contraction plays a tremendous part in the healing of wounds larger than 15 mm. in diameter. My studies[5] have shown quantitatively through experiments on dogs and humans how traction with elastic adhesive may reduce the size of wounds. This may, of course, be accomplished less surely by adhesive skin straps which are gradually laced closer and closer together. This latter method is less efficient since it is very difficult to maintain adherence of the straps for any length of time. When elastic adhesive is used on edematous legs, it must be made tighter and tighter as the swelling subsides. The shrinkage of the leg will also reduce the size of the ulcer in proportion. Over joints no more than the usual normal contraction must be produced by strapping, or contracture and limitation of function may result.

(e) *Promotion of Rapid and Healthy Epithelization.* It is our opinion that if measures are taken to accomplish (a) to (d), inclusive, epithelization will spontaneously proceed with little help. We have mentioned local vitamin application through cod liver oil preparations as being suggested as a means of stimulating epithelization. In general, we prefer this if necessary to other chemicals like scarlet red as possibly giving a more nearly normal epithelial spread and therefore more stable healing.

Strapping. Morison and Carl Beck many years ago strapped the edges of ulcers in various manners with ordinary flamed zinc oxide adhesive strips. In 1932 the writer[7] published a report of a case of leg ulcer treated by circular strapping with

elastic adhesive in which the effect of pressure on epithelization was demonstrated. Here it was found on the removal of the bandage, the turns of which had been applied unevenly, that where "the turns of the bandage had pressed firmly against the tissues, the ulcers were healed. On the contrary, wherever the turns had been too loose, the granulations were exuberant and epithelium had not grown over." (Fig. 6.) This seems to demonstrate clearly the rôle of pressure in holding down granulation tissue thus favoring epithelization. Twyman[31] expressed this view in an article in which he showed a picture of a bridge of epithelium running across the center of a wound strapped with a narrow strip of adhesive. The epithelial bridge corresponded in position and approximately in width to the strip of adhesive. He expresses the belief that epithelium proliferates readily when it is subjected to a degree of pressure which restrains the growth of granulations. Our further experience with the elastic form of the plaster abundantly demonstrates its value in holding down granulations to the level of the skin, thus favoring epithelization.

No matter what antiseptic is used, if the smear and culture from a wound demonstrate a reduction in the number of organisms, healing will be more rapid. Carrel and others have shown that the healing rate is retarded by infection. It must not be overlooked that the advancement of epithelium over the ulcer is itself a powerful weapon in fighting infection. We see this fact demonstrated in the signal effect which pinch grafting has on a moderately infected granulating ulcer. The spread of epithelium on the wound should, therefore, be encouraged in every possible way. The spreading epithelial edge should be protected and kept on the same plane as the granulations ahead of it in the ulcer base.

No matter whether one believes in the spread of epithelium by mitosis or by cell movement (migration), it must be admitted

that the membrane should be protected in order to insure rapid and stable healing.

This brief review of the means at our

Fig. 6. Effect of pressure on healing process. Several ulcers were transected by a pressure crease. Portions of the ulcers where pressure was greatest (b,b) were found to be healed. Portions where plaster was loose found to be still granulating (a,a).

disposal for treating ulcers brings us to the question—Is there a method of choice? The answer we believe is that each patient and each ulcer must be individualized. Since there are many underlying causes as well as many local causes of ulceration, each case must be studied individually and the proper method chosen for it.

A little more than three years ago I published two articles,[6,7] giving results of studies on the effect of elastic adhesive as a local method of treatment upon a large series of leg ulcers extending from January, 1931 through June, 1934. After clearing up underlying general and local causes of ulceration and treating 11 per cent by radical operation, all but 3.3 per cent healed and only 4.4 per cent recurred. I presented evidence which demonstrated that when this material is properly applied, ulcers, even very old ones, will heal in general at a rate more rapid than the ideal rate of healing for recent wounds kept sterile by dilute solu-

tion of sodium hypochlorite as computed by Carrel, Hartman and du Nouy.

After two additional years in which the actual number of cases treated has materially increased, our results are as satisfactory as ever and I feel satisfied that this material is now beginning to occupy the place in the armamentarium of the field which I predicted it would and which it splendidly merits.

The few persons in whose cases healing with the plaster has not occurred have generally been those in whom one or another of the indications for the radical measures described below was present, but who for economic or other reasons have refused operation.

The properties to which I ascribed the effect of elastic adhesive were that it is *perfectly adhesive, semipermeable, persistently elastic, bactericidal in effect,* and *hygienic.* Table 1 shows the typical shorten-

TABLE 1

SHORTENING OF HEALING TIME ACCOMPLISHED BY ELASTIC ADHESIVE*

	Time in Years Ulcer Remained Unhealed While under Treatment by Various Remedies	Area in Square Centimeters at Time Elastic Adhesive Was Started	Healing Time in Days from Application of Elastic Adhesive	Cost of Elastic Adhesive Treatment until Ulcers Healed
Ulcer 1	12	15.0	65	
Ulcer 2	10	41.5	51	
Ulcer 3	7	17.5	38	
Totals	29	~4.0	154	$13.56
Averages . .	9.6 years	24.7 cms.	51.3 days	$ 4.52

* After Douglas, in *Surg., Gynec. & Obst.,* Oct., 1935.

ing of healing time which it accomplishes with great regularity. Experimental and clinical evidence to prove its modes of local action was presented in a second article. Some of these which were proved were that it provides moist healing, thus protecting antibodies from drying, is semipermeable and does not imprison secretions but obliterates dead space, prevents recontamination or reinfection of the wound, favors epithelization and contraction be-

cause of its "glove-like" action and compression of exuberant granulation tissue, and lastly that it protects growing epithelium splints and prevents distortion of the ulcer edges during movement and compresses the veins.

A glance at the indications or requirements (*a*) through (*e*) which we regard as necessary to obtain healing with strong and healthy skin will show that elastic adhesive comes nearer to meeting all of them than any single material. As we have stated before, "it appears to be an effective combination of four methods previously employed. . . . It combines, in one bandage, the protective and supportive qualities of an Unna's paste boot, the elastic qualities of a rubber stocking, the porous qualities of a gauze dressing, the non-slipping fixative qualities of adhesive." It is also very comfortable and economical.

I wish again to emphasize one point. Its value in combating infection is due to its bactericidal action. It is not essentially antiseptic. Its value in comparison to routine warm soaks of boric is plainly shown in Figure 10. This case was one of ecthyma or multiple ulceration of the skin resembling impetigo but probably due to a mixture of streptococcus and staphylococcus, in which, in more than twenty cases strapping with a postage stamp size strip of elastic adhesive left on for a week at a time has been followed by 100 per cent healing with immediate cessation of the formation of new lesions. An article is in preparation reporting these cases in more detail. The effect is undoubtedly due to the local action of antibodies within the confines of the ulcer plus the fact that the infectious material is not allowed to spread over the skin and contaminate new hair follicles.

Full details of technique for using elastic adhesive may be found in a previous article.[6] Here we merely reiterate a few points and more particularly add a few new ones. In order to obtain best results it is extremely important to follow details of technique very exactly.

Preliminary Local Treatment of Ulcer.
In case of marked suppuration the ulcer and surrounding skin is covered with copious gauze dressing which in turn is

FIG. 7. Application of pad cut to shape of depression on small, deep ulcers.

covered with cellophane over all. The latter is perforated in a few places and especially over the ulcer irrigated with warm saturated boric acid or normal saline at four hour intervals. A warm water bottle, as warm as can be comfortably borne, is applied. The packs are changed every forty-eight hours until gross cleansing of the ulcer is accomplished.

Technique of Applying Elastic Adhesive.
Cleaning and shaving precedes application of elastic adhesive. (Fig. 8.) With the heel on the corner of a chair, a figure 8 is placed at the ankle and one proceeds upward with considerable pressure, overlapping one-half to two-thirds the width of the plaster to the patella.* The bandage is changed at intervals of one week (first time) and two weeks thereafter. Over small deep ulcers the first turn is made loose above, or a small piece of plaster is fitted into, the ulcer crater. Cotton or gauze is cut to fit in the dead space. (Fig. 7.) The bandage is then applied as usual.

* We are constantly asked how tightly the bandage should be applied. The main difficulty arises from applying it too loosely; it is difficult to have it too tight except in arteriosclerosis. However, the turns must be very evenly applied so that there are no pressure ridges. (Fig. 6.) At each successive application the spiral edges of each turn of plaster are turned at a different level in order to avoid such ridges.

At current prices we have shown that average cost of the dressing is less than one-half that of other dressings commonly used for ulcers.

FIG. 8. Method of applying plaster. Heel elevated on corner of chair. First turn over dorsum of foot. Second turn forming figure eight around ankle.

Treatment of Ulcers in Which Exudation Is Marked. If local treatment with soaks is not effectual the threads of the elastoplast may be separated by insertion of scissor points a millimeter or two through the plaster directly over the proposed area of contact with the ulcer. Better still in such cases we make a few slits with scissors (not over four or five) in the direction of the stretch of the plaster with the latter folded so that the adhesive side is out. This we term "fenestrated elastic adhesive." It provides excellent drainage, the slits opening up just enough to release the exudate as it forms, the pull of the plaster then closing the edges of the slits together again. An ulcer so treated is shown in Figure 9.

I have used a bilateral or two way stretch elastic adhesive which I have devised and named equiplast on ulcers which have been especially refractory to treatment. Applications of this, while more limited, will be reported as soon as a sufficiently large number of cases is treated. This is put on, stretched equally in every direction and covered with an elastic cloth roller bandage.

Treatment by Antiseptics under Plaster or Incorporated in Adhesive Coating. In very

refractive and persistent infections of ulcers, Dr. Ralph Larsen[32] of our department has suggested and employed ammoni-

of wounds under this treatment and those with elastic adhesive alone. We see no reason why, since zinc peroxide paste
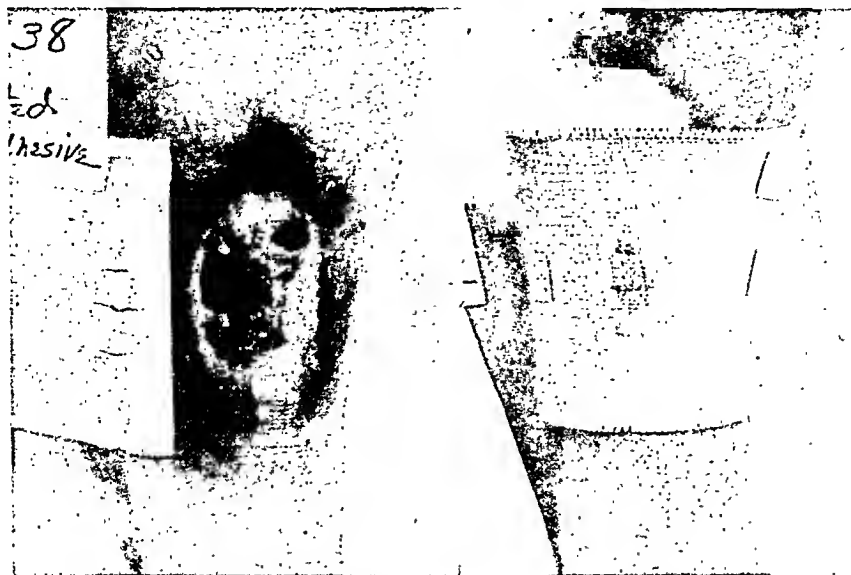
FIG. 9. Application of fenestrated elastic adhesive to ulcer with copious drainage slits cut with sharp scissors lengthwise and folded with adhesive side toward blades.
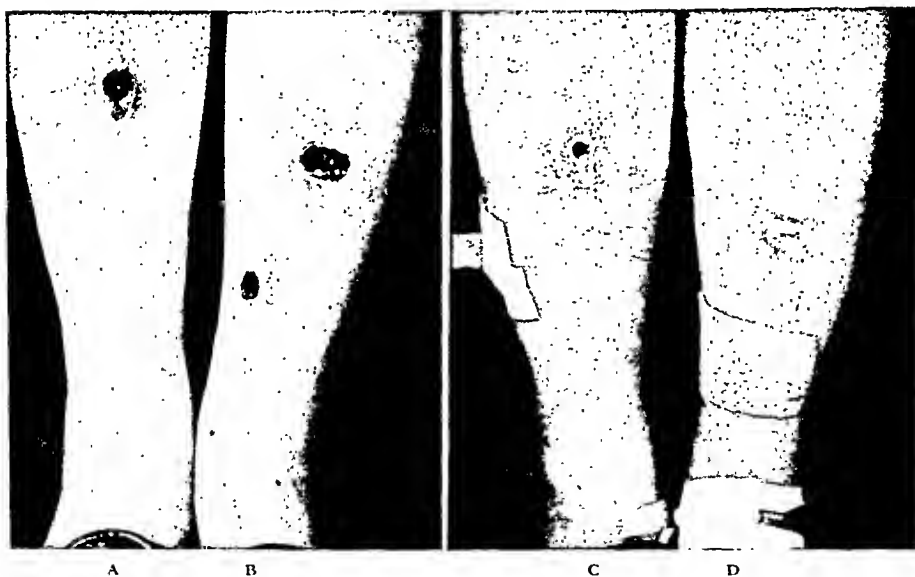
FIG. 10. E. W. Bilateral multiple ulcers of legs due to ecthyma. Effect of elastic adhesive strapping on bacteria. Ulcer on right leg (A), treated with moist, warm, saturated boracic acid compresses, was not sterile for nineteen days and required thirty-nine days to heal. Larger ulcer on upper left leg (B), treated only by strapping at weekly intervals with elastic adhesive, was sterile in nine days and healed (D) in twenty-three days.[7] (From Douglas, *Arch. Surg.*, 32:756, 1936.)

ated mercury ointment 3 per cent as a light coating for the ulcer directly under the elastic adhesive. This seems to offer much hope. At present he and I are making comparative studies by tracings

should not be used in the same manner. The makers of a certain English elastic adhesive have coated the cloth with an emulsion mixed with ichthyol for use in certain cases of eczema surrounding ulcers.

We have ordered elastic adhesive for trial in which the emulsion is mixed with ammoniated mercury and other substances. Results have been so good with elastic adhesive strapping alone that we have been reticent about adding any drug to it unless it can be definitely proved to benefit the healing process.

Materials Used. In our work, both experimental and clinical, we have used principally two forms of plaster, one made in the United States (elastoplast), one in England (tensoplast). Other similar plasters made by good companies are being tried.

Local Strapping. In small ulcers a postage-stamp-shaped strip of elastic adhesive or a circular band or two around the leg will suffice. This is especially true where no veins are to be supported and in those cases in which there is little exudation. In all the corners and edges should be bound down with ordinary adhesive strips.

Contraindications. The contraindications to the use of elastic adhesive are obvious—acute spreading infections where drainage is required, gangrene of the skin from arteriosclerosis and diabetes, projecting bony prominences such as a knuckle of bone in fractures, and severe eczema sensitive to zinc oxide. Ordinary eczema is no contraindication to its use.

Treatment by Transparent Rubber or Composition Jackets. This method, advocated by me in 1936[33] for wounds of the extremities, is now being perfected. By its use the very atmosphere surrounding the wound, i.e., temperature, humidity, solution, or gaseous content, positive or negative pressure, and light conditions may be varied at will while the wound is studied through the jacket under the naked eye and the total exudate collected for study. Exact pressure may be applied to skin grafts and no other dressing applied. Among the successful cases reported have been a graft of the popliteal space and four full thickness grafts of the hand in which takes were recorded with no other dressing.[34] Results are very promising but of course the method requires hospitalization for use on ulcers and grafts of the lower

extremity. Results with it have been reported in a recent article.[33]

Indications for Operation—Radical Treat-

Fig. 11. Squamous cell epithelioma (Marjolin's ulcer) developing in scar thirty-five years after burn. Onset of excruciating pain marked beginning of malignant change. Wide excision and sieve and small deep grafting resulted in healing. Recurrence three years later with amputation.

ment. In a certain few cases, probably due to the fact that the protection to the wound with elastic adhesive is very complete, healing toward the end will be slower even than the normal retardation on ideal curves indicates it should be. We have made it a rule not to discontinue the plaster as long as the tracing of the ulcer edge has shown the slightest degree of reduction in size.

At times alternation of the elastoplast with dry dressings or moist warm boric acid soaks will add a stimulus to which the wound edges will rapidly respond.

In elephantiasis the healing has been slow but progressive up to a year. Patience is required in these cases.

repeatedly recurred with minor injury.

"This list is not to be regarded as exhaustive."

FIG. 12. A, depth of excision necessary for cure of large varicose ulcer. B, lower half of ulcer healed after application of sieve graft. Upper and lateral third healing after same treatment. A pedicle flap has been used to cover tibial crest. C, healed condition several months later.

As we have stated before, "No absolute rules should govern individual cases, our experience would seem to indicate that, in the following types of ulcers, conservative measures should yield at once to radical surgery through which alone permanent cure will be reasonably assured:

"1. Ulcers due to neoplasm.

"2. Ulcers in connection with elephantiasis.

"3. Very large ulcers surrounded and underlaid by avascular scar tissue.

"4. Ulcers in which conservative treatment would involve too great a time loss and too great a risk of further disability on account of recurrence (military and industrial group).

"5. Ulcers which have failed to heal with conservative measures in twelve months.

"6. Ulcers in the region of joints which would heal with scar contractures.

"7. Ulcers which after healing have spontaneously recurred or which have

TECHNIQUE OF RADICAL TREATMENT

By this term in the case of leg ulcers we imply two operations, each of which as a rule should be performed in the hospital. We have not changed our opinion concerning this point though in rare cases minor grafting may be done on ambulatory cases in the out-patient department.

Radical methods should include three phases of treatment.[3,4,5,6]

1. *Preliminary Attention to General or Underlying Causes of Ulceration.* During the period consumed by these measures the patient's general health is looked after, a proper diet prescribed and such conditions as obesity, anemia and nutritional edema are attended to. By the use locally of the Carrel-Dakin technique or some other employing chlorine antiseptic, the ulcerated area is freed of necrotic tissue and the bacterial count is reduced to a point indicating "surgical sterility."

2. *Excision of All Scar Tissue.* The ulcer will promptly recur unless this is

properly done. The débridement is usually performed under a general anesthetic. Briefly the skin incision is carried peripherally as widely as any evidence of scarring is found. The entire ulcer base is then attacked by turning the blade of the scalpel horizontally and undermining it at the level of the deep fascia. No cicatricial tissue must be left. (Fig. 12.) Tendons may be exposed but should not be divided unless lengthening is necessary for contracture. Bleeding is to be controlled by heat and pressure although a few fine catgut ties are permissible. The skin is protected by vaseline gauze strips overlapping the wound edges only 2 or 3 mm. Carrel tubes are placed evenly over the wound in direct contact with its surface. A thin layer of fine meshed gauze is placed entirely over the tubes and wound and fluffy gauze added in many layers to complete the dressing. Irrigations with Dakin's solution or other chlorine antiseptic are begun twenty-four hours later. The purpose of this second phase is débridement of scar and mechanical cleansing, which favor better circulation, through larger vessels. When excision is carried as deeply as it should be, it results in an anastomosis of the superficial and deep lymphatic vessels at the edges, which is also highly beneficial. Many ulcers involve a considerable portion of the leg. It is therefore better as a rule to divide the operation into two or three stages. One of our patients was cured after transplantation of 105 square inches of whole thickness skin to two legs. This was done in four stages by overlapping the successive grafting and excision operations respectively.

3. *The Repair of the Defect.* The operation to supply skin or skin and subcutaneous tissue to the defect should usually be delayed for four or five days. One important reason for this is that the products of trauma from the excision will have been absorbed or cleared from the surface; the second, as pointed out by Carrel and Dehelly, is that the deep cicatrix may contain encysted organisms, which may infect the surface of the wound at the time of excision when tissues are damaged and blood

clot is present to form an ideal culture medium. We are aware that certain surgeons advocate immediate grafting after excision of ulcers, while others go to the other extreme of waiting as long as three or four weeks. We feel that the latter is usually unnecessary. The former, for the reasons given,[6] is not safe, except in excision of healed scars, and not always even in these. Immediate grafting in large wounds may prolong the operation to an undesirable length. It is usually advantageous not to disturb the lower layers of gauze in contact with the wound until the time of grafting.

METHODS OF CLOSURE

(a) *Pedicle Flaps.* If a sharp tibial crest is exposed without periosteum, holes should be bored in the bone to allow granulations to cover its surface. This is a method practiced on the skull in the case of scalped persons by Vance in Tennessee in the Indian wars of Andrew Jackson's time. A pedicle flap of skin and subcutaneous tissue may then be swung from one of the margins of the wound into it (the ancient Indian method). This maneuver shifts tissue to a better position where it is more needed but does not gain tissue. It usually has to be combined with skin grafting. Figure 12 shows such a case. Deep defects over joints may also need covering with a flap.

The use of pedicle flaps from the opposite extremity (Italian method) has a very limited application. The reasons for this are frequently the presence of disease on the other extremity (varicose veins), irksomeness of holding the two legs in apposition, and extra time consumed.

(b) *Skin Grafts.* For the detailed technique employed in the use of the various kinds of skin grafts, reference is made to special articles and texts on the subject.

Varieties. 1. Thin Grafts.—Ollier Thiersch. These consist of thin large sheets of skin, usually cut with a razor, the skin being held taut between the edges of two boards. This graft often fails from the standpoint of resisting infection and of preventing contracture.

2. Intermediate Thickness Grafts. Through the use of an ingenious vacuum cutting chamber and a special long, thin-bladed knife, Blair and Brown[11] have shown that it is possible to split the skin and to vary the thickness of skin grafts of the Thiersch variety at will so as to include more or less of the derma, producing, as they term it, a thin or thick "split" graft, which respectively will include approximately one-third to three-fourths of the thickness of the derma. This is an excellent graft and has many important and useful applications. Its successful use in grafting leg ulcers has been reported by Brown, Byars and Blair.[11] They used thick split grafts. The split graft requires a certain degree of skill and special apparatus. The thinner variety will allow of a certain degree of contraction. The donor area heals without further grafting and may be used for further cutting of grafts.

3. Grafts of Whole Thickness. (a) Small deep or "pinch" grafts. Davis has pointed out the great usefulness of small deep grafts (popularly called "pinch" grafts) for covering ulcers in hospital and in selected ambulatory cases. Reverdin, whose very minute grafts have fallen into disuse, is responsible for developing the method of cutting these grafts. They are cut by lifting the skin up like a tent with the point of a sewing needle and cutting small circular pieces from under it with a scalpel. These grafts often take in spite of a fairly marked degree of infection. They give a healing which in appearance is like a mosaic but fairly resistant. Another disadvantage is that they will fail to prevent contracture, a point important in the region of joints.

(b) Whole thickness or Wolfe Krause Grafts are cut in any size by pattern to cover any defect. They consist of the full thickness of the skin down to but not including the underlying fat. The donor area must be closed by suture or by further grafting. Like "split" grafts they must be sutured in place and pressure maintained over their surface for about three weeks after operation with a marine sponge,

inflatable rubber tampon (Smith), anthrax-tested lamb's wool, still attached to the lamb's skin, a material which I suggested two years ago for this purpose and have found to be very valuable.

(1) The "sieve" or perforated graft, a modification in which islands of skin are punched out with a small round cupped steel die before cutting the full thickness of skin, was described by the writer in 1930 for use in large defects. Since then excellent reports of results have been received from many clinics and many individuals. Some surgeons have reported its successful use in ambulatory cases. At present a report on a great many cases treated by this form of graft is in preparation. It has been demonstrated, on account of its drainage at every point throughout its extent due to its uniform perforations, to possess a degree of safety in the face of infection, which places it in a category with small deep grafts. On the other hand, the type of healing obtained through its full thickness skin is stable and prevents contracture. The donor site will heal spontaneously in 100 per cent of cases without further attention except for a few dressings. We have here a sharp contrast to the Wolfe-Krause graft which requires grafting of the donor area. Other techniques of skin grafting, such as the burying of "pinch" grafts or strips of skin by pushing or pulling them into the granulations have a limited use in ulcer surgery. They may be applicable to certain cases but the advances recently attained through other methods of skin grafting have made these appear to have rather limited value. The type of healing obtained in leg ulcers by the use of sieve grafts has proved over a period of years to leave little to be desired in our cases.

Because of skill or experience a surgeon may obtain better results through the use of one kind of graft or another. This is entirely permissible, within limits. He should not forget, however, that there are certain indications, such as safety, stability of healing, and prevention of

contracture, which must be followed to obtain the greatest measure of success. No one method will suit all cases. The effort should be made to individualize each patient and to choose the proper method of grafting for each. I feel very certain that "whole thickness skin" grafting or a skin graft so thick that it deserves the name should be used without exception on an extremity over a knee or ankle joint. (See Fig. 1.) Only by so doing will contracture and consequent loss or limitation of function be avoided.

CONCLUSIONS

Ulcer of the leg, except in extremely advanced cases, is curable with little loss of function and few recurrences through an individualization of the particular case in hand. Cure may be accomplished in a vast majority of cases by attention to underlying causes of ulceration, and by employing the local conservative methods, experimental and clinical evidence for the value of which is presented. The remaining small percentage of cases may almost all be cured by excision of the ulcer followed by skin grafting.

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ULCERATION OF LOWER EXTREMITIES AND SKIN GRAFTS

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FROM a study of a group of patients sent into the hospital for repair of ulceration of the lower extremity, it appears that, where a large amount of skin has been lost, the best repair will be by the replacement of normal skin.

Nineteen different causes of ulceration have been found, but there is a surprisingly small percentage of varicose ulcers. The longest duration of continuous ulceration was twenty years, in a woman who had dressed three huge open areas every day over this entire period. Another ulcer was open and closed for forty-four years.

If there is complete circular loss of skin, spontaneous epithelization is greatly retarded, and there may be a complete lack of growth from the lower epithelial edge. If just a little bridge of normal skin is left through the full length of the leg, spontaneous epithelization may occur very rapidly and occasionally give a permanent bearing surface. There is, however, a tremendous individual variation in the rate and possible extent of surface healing in these patients.

Some patients never produce any real granulations on the ulcer bed, but continue to have a dirty gray or yellow glistening base. Although this base may never be made clean, it may be excised and successful grafting done. More troublesome is the lesion that has developed an excessively thick, dense scar, the removal of which carries one down to bone or tendon; and perhaps still more hazardous for a successful repair is the occasional lesion that has a deep edema under the ulcer base, suggesting possibly the beginning of an elephantiasis.

Spontaneous healing of permanence cannot be expected in ulcers due to arterial disease or to excessive radiation.

Various microscopic pictures of the ulcer edge may be found. There may be a marked activity of epithelium as evidenced by excessive keratinization and indicating a stimulus to epithelial proliferation by the wound itself but with no success whatever in covering the defect. This type of benign activity might be the most responsive to conservative methods of treatment such as elastic adhesive strapping, if the total area is not too prohibitive.

Another type of edge may show practically no epithelial activity and no tendency for deep invasion. From these types any degree of epithelial activity up to squamous cell carcinoma may be found.

The "scar" epithelium that covers these defects spontaneously under conservative treatment may give a permanent bearing surface in some instances, especially if the area is not too large, but it is not normal skin and can be easily traumatized with resultant recurrent ulceration and very slow healing. This epithelium creeps across the scar base, does not contain hair or glands and does not have normal derma to attach it to the base. Slight infection or trauma may cause widespread denudation of this thin, flat "scar" epithelial growth.

Free thick split grafts are suitable for the repair of leg ulcers for the following reasons: (1) They can be obtained in large amounts

rapidly and easily. In one patient 128 square inches were covered and in another almost the entire lower leg was covered at

in some instances, or in patients unsuited for any other type of repair. These were used once in this series after failure of a

FIG. 1. A, complete circular loss of skin one and one-half years following burn. There is excessive keratinization around the edges but no effort to bridge across in healing. B, complete healing in one operation for each leg in which the area was excised and the defect covered with thick split grafts.

single operations. (2) They may be gotten of suitable thickness to give normal appearance, and a normal bearing surface that will withstand trauma. (3) The donor area from which they were taken heals rapidly without deformity. (4) They can withstand transplantation into a contaminated field. (5) Because of general ease of handling this graft, large areas, including unstable surrounding scar epithelium, are more apt to be grafted. This is especially important where an entire leg may have to be covered before the patient is through. (6) The postoperative care both for the patient and for the surgeon is relatively easy. (7) Any secondary operations can be done early. (8) The use of any type of full thickness graft is not thought necessary, and, on an infected field, it is not practical.

Qualifications of this choice of thick split grafts may, of course, be made: (1) Pinch grafts or small deep grafts may advantageously be used without hospitalization

split graft because of a mistake in technique. (2) Double pedicle or sliding flaps may be used, in osteomyelitis cases, to insure a thicker covering over the tibia. (3) Individual preference of the surgeon for some type of full thickness graft which, if successful, will, of course, give as satisfactory a result as the thick split graft.[3]

It is unnecessary to mention that any causative factors should be controlled if possible before grafting. Improvement in circulation and control of infection are probably the most important early steps. If the patient comes in with a dirty wound and surrounding area, he is usually given soap, water, and a brush and asked to do the best he can in the bathtub. Ointments or cold cream may be used if necessary to loosen crusts and heavy keratin deposits, and gentle surface débridement is carried out. Continuous wet dressings either of saline or Dakin's solution are then kept on the area, with the patient in bed and the

leg elevated most of the time. It is perhaps best to use some mild application at the time of each dressing, such as 5 per cent

being judged by its appearance. However, if the lowly pyocyaneus is known to be present, it is best to delay operation until
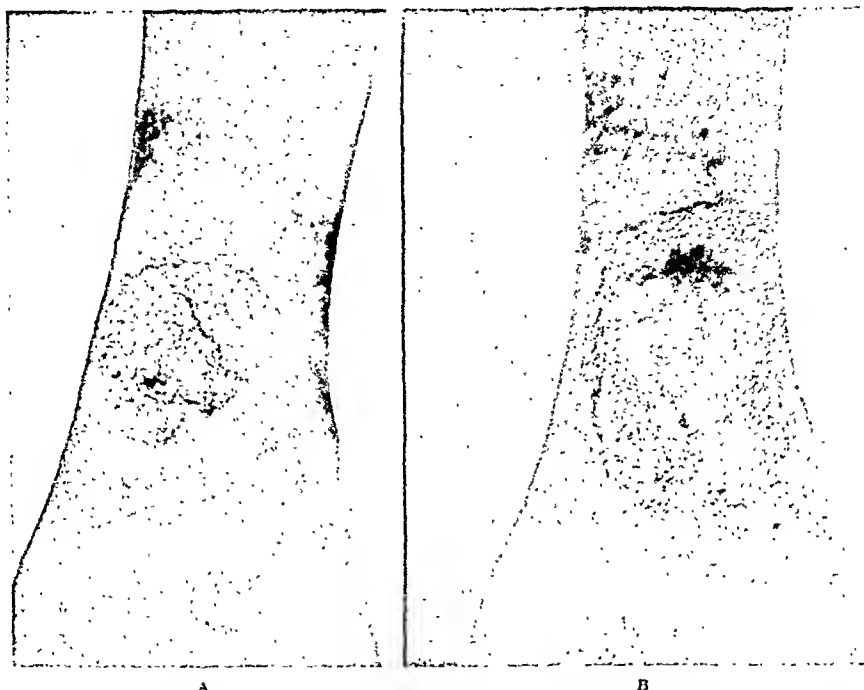
FIG. 2. A, ulceration of ten years' duration in a patient with arteriovascular disease plus a local x-ray dermatitis. This photo shows a loss of graft following the first operation. B, shows leg after a second thick split graft application. Well now five years.

gentian violet or other of individual choice. Very fine mesh bandage gauze or old linen placed next to the wound is of greater benefit than the usual coarse mesh dressing gauze. In extensive areas and in badly infected wounds, the continuous saline bath is used for one to three hours a day.

Elastic pressure bandages are frequently used and this pressure may improve the entire aspect of the leg within twenty-four to forty-eight hours. These preliminary pressure dressings may even be substituted for bed rest over several days' time.[3]

No patient is operated on if there is any evidence of cellulitis or edema anywhere, and patients have been kept in bed as long as three weeks before operation. It is, of course, hoped that the ulcer might be sterile, but it is doubtful if one of any size is ever entirely free of contamination. Routine preoperative cultures are not done, the readiness of the wound for grafting

this is controlled, for it is extremely harmful to the growth of free skin grafts. It is also very important that any active ringworm infection be controlled.

Local preparation is done with soap, water, ether, and 2 per cent iodine. The ulcer edge and base are excised down to a suitable bleeding surface, by undercutting (never scraping) with a knife, care being used not to expose bone or tendon; any adjacent thin "scar" epithelium is removed with the knife and the resultant defect is bound firmly with saline gauze after any necessary bleeders have been tied with very fine silk.

Granulations must be very carefully removed if there has been recent healing over exposed bone or tendon; and, if a deep avascular base persists in spite of deep removal, it may be better to risk putting grafts directly on this rather than exposing bare bone or tendon by still further dis-

section. Grafts will grow on bone covered with periosteum but not where it has been stripped.

or basted along the edges with running sutures; more running mattress sutures through the surface of the graft bind it
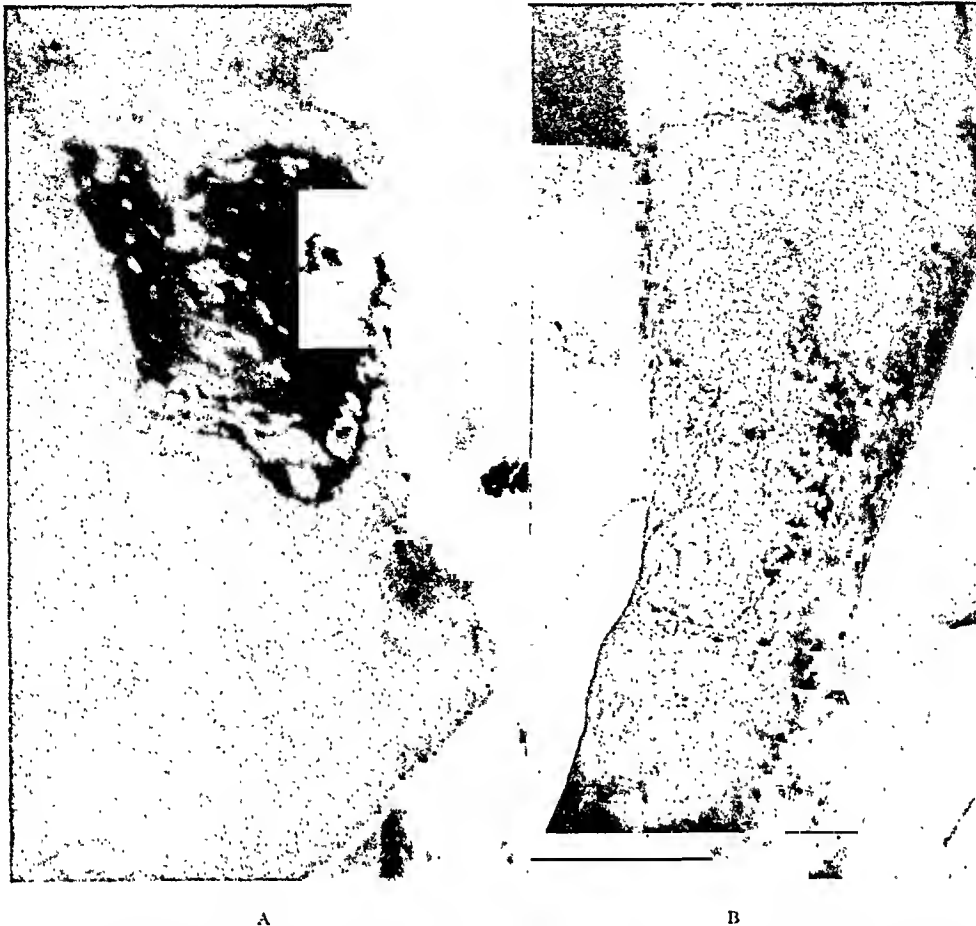
FIG. 3. A, this ulcer had been open and closed for forty-four years following trauma at the time of a milk-leg. B, healed in one operation and remained so until death from other cause.

In long standing ulcerations there may be such a thick scar formation that a blood supply to a graft cannot be maintained and, even though the graft looks viable at the first dressing, it may be progressively lost. If this situation can be recognized, much trouble may be avoided by being sure to remove completely the avascular scar. If it is over a large surface, small areas can be done at one time rather than make the procedure too formidable.

Thick split grafts up to three-fourths the thickness of the skin are obtained, usually with the aid of the suction retractor, from the same or opposite thigh, if possible in one piece large enough to cover the whole defect.

The graft is applied directly to the base, slightly overlapping the edges, and whipped

down to the bed of the defect. If more than one graft is used, their edges are overlapped. Multiple stab holes are cut in the graft to allow for drainage. Several layers of wet gauze are smoothly applied, tubes for irrigation are incorporated, good firm pressure is obtained and a dressing is applied.

Postoperative Care. The original dressing is kept wet with saline introduced through the irrigation tubes. After a good many observations we have concluded that the use of the continuous wet dressing gives a better chance of "take" than a dry or a grease dressing, but, occasionally, if the ulcer bed is clean enough, a simple grease-gauze pressure dressing is used.

After four days the first dressing is done, the sutures are removed and the over-

lapping edges trimmed away carefully. One per cent silver nitrate, 5 per cent gentian violet or some other mild antiseptic is

stances of infection, if an active fight is begun immediately and carried on over several days, much surface area can be

FIG. 4. A, small ulcer recurrent for thirty years in the scar epithelium over an old osteomyelitis scar; patient had had trouble in securing employment because of it. B, at one operation the whole scar area was removed and covered with a thick split graft with complete healing resulting. Well four and one-half years.

gently painted over the edges and surface. The graft and surrounding areas are usually found so clean that wet dressings are no longer necessary and one or two layers of fine mesh gauze impregnated with 4 per cent xeroform, 5 per cent scarlet red or 5 per cent zinc oxide are applied. A good firm pressure dressing is put over this and any necessary joint fixation is continued.

If there is fluid, pus, or blood under the graft, it is evacuated through new small openings; if there is evident loss of any area with a gross amount of pus around it, the dead graft is trimmed carefully away; if there is Bacillus pyocyaneus infection present, the whole surrounding area is washed with soap and water. In these in-

saved. Antiseptics are used locally, fine mesh gauze is applied smoothly over the whole area, and a wet dressing is reapplied. Adequate irrigation with Dakin's solution or saline is maintained to insure continual wetness, and the dressing is carefully changed each day.

After a few days, in clean cases and as soon as infected cases have become clean, the usual grease gauze or sterile cold cream is used over the area, and, after suitable padding is in place, an elastic bandage is applied. Walking should be prohibited for two weeks and activity curbed for another week or two after this.

The patient is sent home with the elastic bandage in place to be worn while up and

around until no cyanosis appears in the graft during activity. If this continued pressure is neglected, there may even be small hemorrhages under, and into, the graft.

If the graft is directly over the shin or ankle, it should be further protected with padding for several weeks.

A late source of annoyance in some patients is the collection of sebum in and under the graft; this occurs first as small raised lumps and, where recognized, these should be evacuated by fine openings over them. If this is not done, these areas may become infected as an ordinary pimple and the pus may dissect under the graft and actually cause some surface loss.[3]

Percentages of cures are misleading because it is recognized that many patients may develop another ulcer at any time; however, it is probable that all patients can be kept well if they will report for treatment.

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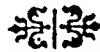
INTERNAL DERANGEMENT OF THE KNEE JOINT

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THE writer proposes in the following article to confine himself to a consideration of those points which he has found to be of a practical value, and for the sake of brevity to omit any detailed description of the anatomy or applied physiology of the knee joint—although an appreciation of both is essential to a proper understanding of the various lesions of this joint. There are many causes of "internal derangement of the knee," which is a convenient, but somewhat loose general descriptive term. The practical problem is how to diagnose between a sprain, acute or chronic, and a mechanical upset to the joint mechanism, such as is caused by a torn and displaced semilunar cartilage, or more rarely a loose body in the joint. The whole question of treatment depends on the accuracy of this diagnosis.

THE EXAMINATION OF THE PATIENT

History. A careful history is the first essential. The importance of an accurate description of the patient's symptoms, and an orderly account of the various details, from the time of the very first symptom, cannot be overstressed. In the vast majority this is the most important part of the examination. It may well take fifteen or twenty minutes to piece together the story of the original injury and the immediate after happenings, in order to get a clear and accurate picture of the sequence of events.

The points in the history which must be carefully weighed are many. First, consider the details of the original injury.

There are three main types of injury to the knee which are distinct as regards mechanism.

1. *Lateral strain*, commonly caused by external violence forcing the patient's knee into abduction, and so tearing part of the internal lateral ligament. The femoral attachment of this ligament is almost always the part which bears the brunt of the trauma. The reverse force, when the knee is forcibly adducted, is less common. The external lateral ligament will then be torn, not infrequently combined with avulsion of bone from the head of the fibula.

2. *Rotation strain* results from a twisting force. This will result in a tear of ligaments. The ligament that suffers is the coronary, which attaches the semilunar cartilage to the head of the tibia. This injury is common, and failure to recognize its results will render the surgeon liable to open many knees unnecessarily. It occurs at all ages. In practice we see it most often in an aggravated form as the result of a fall in skiing, although it may result from any twisting injury. The rotation strain may also injure the semilunar cartilage if the foot is firmly gripping the ground, as with the heavily studded shoe of the modern footballer, with the weight on the leg and the body twist. The muscle, caught at a disadvantage cannot check the movement, and the strain falls on the second line of defense, the ligament. *The primary injury to the cartilage is a longitudinal tear or split in the substance of the cartilage, caused by direct compression or grinding action of the femur on the tibia, caused by a rotation force, when the weight is borne on the leg with the knee flexed.*

A consideration of the history of a primary injury which has given rise to a torn semilunar cartilage will usually be found to contain these three factors—the flexed knee, rotation, and weight-bearing. This triad is not necessary for a second or subsequent displacement, for, as is well

known, the cartilage may then easily become displaced. This can even occur while the patient is lying in bed.

3. *Hyperextension strain*, the knee forced beyond the normal 180 degree extension. This may result in a tear of the anterior crucial ligament. Alternatively the ligament may tear away with its tibial attachment, "avulsion of the tibial spine."

"LOCKING AND UNLOCKING"

The phenomenon known as locking is often regarded as diagnostic of a displaced cartilage, or a loose body—but locking which means inability to extend the knee may be a symptom of a severe sprain. A patient with a torn internal lateral ligament may be unable to straighten the knee, which is held semiflexed by protective muscular spasm.

The less well appreciated *unlocking* is diagnostic. If a knee, as the result of an injury, will not straighten, and if the patient or a friend or a doctor takes hold of the leg, manipulates it and quite suddenly it will straighten, then the cause of the flexion must be mechanical. This means in practice a torn cartilage which was displaced and blocked extension, or a loose body jammed between the bearing surfaces.

The typical history of internal derangement caused by a torn cartilage is characteristic: A patient states that his knee was injured at football a year or two previously and since that time has given way on some four or five definite occasions; that he fell because the knee gave way and not because he was tackled; that the knee would not straighten and that he was assisted off the field limping, with the toe but not the heel on the ground; that someone pulled his leg straight, he felt something move in the joint and was then able to straighten and bend the leg; and that the leg swelled the same evening. From such a history, the diagnosis of recurrent displacement of a torn cartilage is simple.

PRIMARY INJURY

The diagnosis of the *primary injury* to a semilunar cartilage is much harder to arrive at. Tenderness elicited on palpating the joint line is suggestive. This is generally found soon after the accident, except in a patient with a history of many similar attacks. Tenderness should be looked for, as it is the sign on which one relies for the decision as to which cartilage is at fault.

Fluid in the joint will result from any injury which damages synovial membrane, i.e., a sprain or a torn cartilage. A hemarthrosis suggests fracture, i.e., an avulsed tibial spine.

The age of the patient is noted, because we know that it is rare to find a torn cartilage in a child, and indeed under the age of 17. We meet with congenital variations in the external semilunar, but these are rare. Similar variations in the internal must be very rare. I cannot recall an example in my personal experience. It follows that in a child we shall be very chary of diagnosing an internal derangement of the knee as a torn cartilage, and in practice shall do our best to avoid operation on the young.

Again after the age of 35 to 40, torn cartilages are uncommon. Here the symptoms of pain and pseudo-locking but without unlocking, and general feeling of insecurity are more often caused by a mild chronic arthritis. The knee joint in patients of 40 to 50 will give rise to symptoms perhaps crudely mimicking internal derangement on overuse.

DIFFERENTIAL DIAGNOSIS

The differentiation of torn semilunar cartilage from the other conditions which give rise to somewhat similar symptoms and clinical findings, must be briefly alluded to, but the question of the "sprained knee" will be considered more fully. As has already been said, this is the real difficulty, and as treatment necessarily depends on diagnosis its importance cannot be overstated.

Abduction Sprain. The story of the injury may be helpful—the patient may be able to describe an accident clearly indicative of an abduction force. The knee may

well be "locked," and in a severe injury this feature is not uncommon. The diagnostic feature is the site of tenderness on pressure by the examining finger. This is on the medial condyle of the femur and above the joint line. It is true the joint line far back may be tender too. Again with a severe sprain there may be swelling and edema over the ligament, not very pronounced, but still easily discernible. Attempts to straighten the knee give rise to pain, and flexion too may be limited.

Rotation Sprain. A similar history is obtained—a swollen knee with fluid and general tenderness, extension and flexion limited if the injury is severe, inability to take weight on the leg, except with the knee flexed and the toe only on the ground.

The differential diagnosis between this injury and a recurrent cartilage lesion is easy by the history, but between this and a primary injury to the cartilage is often impossible. We treat such a lesion as a sprain and we await events. Once recovery has taken place there is no recurrence following a sprain; following a torn semilunar there will be recurrence. I would emphasize the need for this policy of waiting on events, for unless we are alive to the difficulty, and appreciate the close resemblance of the symptoms and physical signs of a torn cartilage and a rotation sprain, we shall operate needlessly.

Loose Body. This lesion is characterized by repeated "locking" with ease of unlocking. It is diagnosed with certainty only if the body is felt by the patient or the examining finger, or is visible in a skiagram.

It should be noted that loose bodies are relatively uncommon in the young. It is not until we come to the age period for the osteoarthritic knee, and the detached osteophyte that we meet with many examples.

Fat Pad. The signs and symptoms of injury to the retropatellar fat pad will simulate a cartilage injury, but are generally less severe. There may be a history of pseudo-locking, but there will be no history of unlocking. Local tenderness on pressure is often experienced on the joint line. The patient complains of his knee giving way, of having a knee he cannot trust. In the writer's experience, this trouble with the fat pad is more common in patients over thirty or forty years of age.

Overuse Arthritis. By this term we refer to the type of knee, generally between the third and fifth decades, which stands up to ordinary use but gives rise to pain or aching, swelling and discomfort if excessive use is demanded of it. Prolonged and unusual exercise following on a sedentary life, may give rise to the symptoms. On consideration of the history there is really nothing which denotes a mechanical derangement, symptoms are gradual in onset, and cumulative. On examination of the joint there are two salient points to be noted, viz.: pain on forced extension (a sharp but quite small jerk towards extension brings on the pain), and localized tenderness on pressure over the joint line, far back and always in the same place. If the knee is examined bent to a right angle over the side of the couch, the tender area, small and localized, is on the joint line just where the femur and tibia meet.

Torn Crucial Ligament. Diagnosis here is simple. The laxity of the joint which permits of the gliding forward of the tibia on the femur when the knee is examined in right angled flexion is characteristic. The range should always be compared with that obtainable on the sound side.

Avulsion Fracture of Tibial Spine. This can definitely simulate a primary cartilage injury. X-ray examination clears up the diagnosis. It should be borne in mind that an x-ray is an essential part of the clinical examination of every joint.

Recurrent Dislocation of the Patella. This again merits attention. An examination of the side to side excursion of the patella should be made. It is to be borne in mind that mistakes can be and are made. In our own series we have on more than one occasion fallen into this error and explored the knee. Subsequent attacks which the

exploratory operation naturally failed to prevent, established the true diagnosis.

Fracture of the lower pole of the patella, joint disease and allied conditions should give rise to no difficulty in diagnosis.

TREATMENT

The treatment called for in any particular patient depends on one's estimate of the pathology of the joint condition.

A sprain calls for protection of the ligament from further strain during the healing process, while at the same time the patient is encouraged to keep the joint moving and to hasten the restoration of function by active use. In the early stages electrical stimulation with a faradic coil of low voltage will be of great assistance in restoring tone to the muscles and hastening recovery.

The abuse of *rest* must be alluded to. Rest may be needed for a day or two if the injury is severe, but prolonged rest has no place in the treatment of joint injury. The failure to appreciate this point is responsible for many failures in treatment, rest and fixation leading to the formation of capsular and intracapsular adhesions. A rotation sprain if treated by immobilization will in the ordinary process of repair be followed by organization of outpoured lymph and blood and the formation of fibrous tissue. This is especially likely to happen in the loose areolar tissue that fills the space between the coronary ligaments and the capsule. The normal excursion of the semilunar cartilage is prevented and strain on such an adhesion during movement gives rise to a feeling of weakness, pain and insecurity of the joint.

Forced mobilization under anesthesia, the so-called breaking down of adhesions, is needed for a chronic or a neglected sprain. If employed too early, e.g., in the early stages because the knee is held flexed by muscle spasm, it can do nothing but harm, and retards recovery.

Forced mobilization may be employed empirically for patients in whom the diagnosis is doubtful. If a knee has been given a period of rest following an injury and fails to be restored to normal, the surgeon may be in doubt as to the differential diagnosis between a rotation sprain and a torn cartilage. He will be wise to try the effect of manipulation before advising operation on the joint.

There is no doubt that many knees have been cured by the unqualified bonesetters after operation has been advised and refused. A true estimate of the pathology provides the explanation, for adhesions are cured by manipulation.

Torn Cartilage. Once the diagnosis is established, operation should be undertaken, for a displaced cartilage is a torn cartilage, and a torn cartilage is incapable of repair.

THE OPERATION

No detailed description of the operation will be entered into here, but certain points in connection with it which the writer has found of importance will be emphasized. (A full account of the operation, together with the anatomy of the posterior approach of the knee appears in *J. Bone & Joint Surg.,* 17: 605, 1935.)

The operation should be carried out under a tourniquet after careful preparation of the patient, and with a rigid aseptic, non-touch technique. Extreme gentleness must be insisted upon and no bruising of tissue or pulling with heavy retractors is to be permitted. The skin incision is a matter of individual preference. The writer prefers the oblique incision as it is wise to avoid injury to the patellar branch of the saphenous nerve which may otherwise give rise to trouble in that the nerve may become involved in the scar.

It is foolish to cramp oneself by not having a sufficient exposure, but the big incisions—either the split-patellar or the para-patellar incision—are not necessary. Although these long incisions may be useful in searching for a loose body or for operation on an avulsion fracture of the tibial spine, they give poor access for the removal of the semilunar cartilage.

Big scars in synovial membrane are to be avoided. If necessary, multiple incisions can be used and may be needed for removal

patient—some knees are fairly lax, some are tight.

This approach is most often needed for
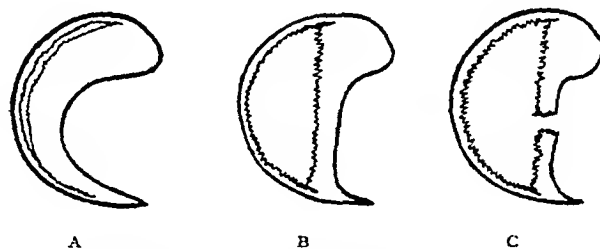
FIG. 1. Diagrams of complete longitudinal tears. A, with no displacement. B, the bucket handle displacement. C, with added rupture of the central displaced portion. (From Bristow, in *J. Bone & Joint Surg.*, 17:605, 1935.)
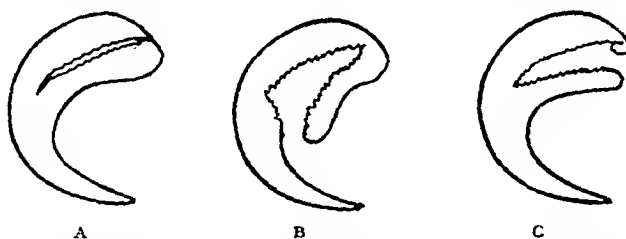
FIG. 2. A, diagram of posterior longitudinal tear. B, displaced with anterior end force. C, similar displacement, but with posterior attachment torn off. (From Bristow, in *J. Bone & Joint Surg.*, 17:605, 1935.)
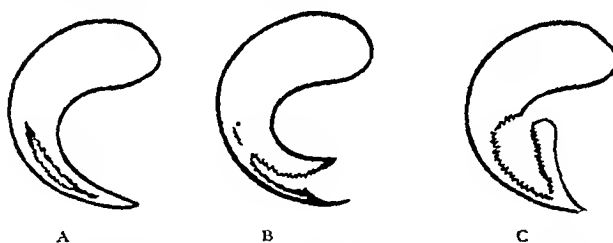
FIG. 3. A, diagram of anterior longitudinal tear. B, anterior end torn and displaced. C, posterior end of tear displaced. (From Bristow, in *J. Bone & Joint Surg.*, 17:605, 1935.)

of loose bodies, or a second incision may be required to remove the posterior horn of the cartilage.

The Posterior Approach. The surgeon must be prepared to explore the back of the joint, although this should not be part of the routine operation, as it is unnecessary and has certain obvious disadvantages.

The objection to the posterior approach is that the view of the joint is restricted, and that the incision, necessarily longitudinal, has a tendency to become keloid. As with the anterior approach, the view seems to vary according to the individual

the removal of loose bodies in the posterior compartment of the knee.

If, on opening the knee, one sees a bucket-handle tear with the center portion displaced and running backwards across the joint, then removal of the displaced part and of the peripheral part as far back as convenient is the wisest course.

If the joint looks normal when opened, the anterior third or half of the cartilage must be freed and pulled; then, if there is a posterior longitudinal split, the cartilage will be displaced across the joint. If the posterior part of the cartilage is not torn—

in other words, if the cartilage is normal—it will not be displaced when pulled. Unless the surgeon is prepared to detach the normal front end, he will often fail to recognize the posterior longitudinal tear. This tear is common, occurring in some 30 per cent of the cases operated upon.

If the posterior half has failed to pull across the joint, the anterior part, already detached by the surgeon, must be removed and the fixed posterior part left.

The amount of the cartilage which can be removed via the anterior incision varies considerably with individual patients. In some, only a bare two-thirds can be removed; in others four-fifths, or nearly the whole, can be detached.

The wound is closed by a continuous catgut stitch, first taking in the synovial membrane, and second the capsular layer. It is important to catch in vessels in the first stitches, particularly towards the area of the fat pad. The skin incision is closed and a tight pressure bandage is put on the knee.

POSTOPERATIVE TREATMENT

The tight bandage is left in situ for twenty-four hours, and is then cut through without disturbing the underlying dressing.

he should be able to raise the limb from the bed and to tighten and relax the quadriceps. Electrical stimulation of the quad-

Fig. 4. Incision (dotted line) and skin marking of patellar branch of internal saphenous vein. (From Bristow, in *J. Bone & Joint Surg.*, 17: 605, 1935.)

riceps is commenced on the sixth day or earlier, and on the eighth day the stitches are removed.

The patient is up and walking on the tenth day. His early efforts at walking are supervised by the masseuse in order to
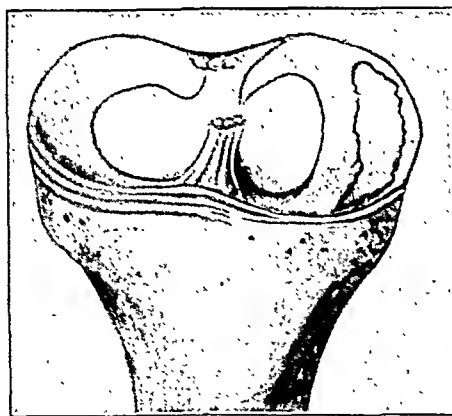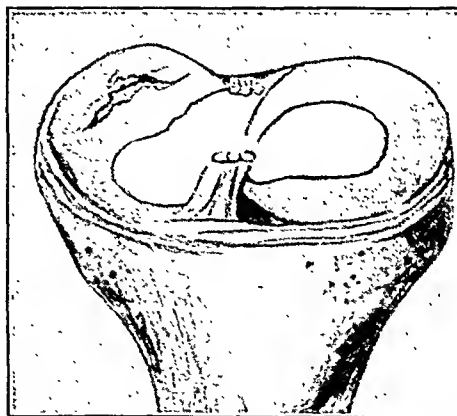
Fig. 5. Two stages in the tear and displacement of the internal cartilage. A, complete bucket handled displacement, the commonest type. B, posterior longitudinal tear, as found in 31 per cent of cartilage displacements. (From Bristow, in *J. Bone & Joint Surg.*, 17: 605, 1935.)

The patient is encouraged to move the leg in bed and to contract the muscles voluntarily. At the end of forty-eight hours,

teach him to take an equal length of stride with each foot and to bear his weight symmetrically. Small details of this kind

are worthy of attention, as they hasten convalescence.

The need for postoperative treatment should be emphasized, and it should be borne in mind that the quadriceps is the only safeguard against rotation strain. If the muscle is much wasted, it should be built up before operation, as this helps a speedy recovery.

After operation, the muscle treatment must be carried out daily, as a routine. The recovery of movement is regained by the patient's own voluntary efforts. No passive or forced movements are needed, except in so far as the masseuse must see that rotation in both directions is assured during flexion.

On an average, after a cartilage operation, the patients can return to office work in from two to three weeks and resume active game-playing in from six to eight weeks. There is generally some fluid in the joint when they commence to get about again, but this calls for no special care and subsides quickly. If this fluid is excessive, it is advisable to apply a small crepe bandage for a week or two. If the fluid persists, it should be aspirated. Physical treatment, especially electrical stimulation of the quadriceps, aids recovery. Rowing on the sliding seat and bicycle riding are two excellent aids to strengthen the thigh muscles.

RESULTS OF OPERATION

A study of this analysis (Table I) in a personal series shows that the relative frequency of injury to the internal semilunar cartilage over the external semilunar cartilage was nearly five to one—a lower figure than is generally given, but substantially the same as that found in all cases at St. Thomas's Hospital during the period 1926 to 1930—namely, six to one.

The seventy-seven cases composing the groups listed as "normal and hypermobile" make up about 10 per cent.

As shown in Table II, the posterior tears formed 31 per cent of the 791 longitudinal tears of cartilage found at operation. This

figure is significant, for this lesion may easily be missed unless the surgeon is on the lookout for it and recognizes that it is common.

TABLE I

ANALYSIS OF 956 OPERATIONS FOR INTERNAL DERANGEMENT OF THE KNEE JOINT TO JULY 1938

(Excluding operations for removal of loose bodies)

Findings	Internal Cartilage Cases	External Cartilage Cases
Longitudinal tears..............	650	140
Cysts......................	22	27
Congenital complete disc........	0	3
Loose posterior end after removal of anterior two-thirds........	5	0
Indefinite, old tears, scarring....	25	4
Fibrosis of fat pad, complication anterior tear.................	22	1
Normal and hypermobile........	62	15
	766	190
Total......................	956	

TABLE II

ANALYSIS OF 791 LONGITUDINAL TEARS OR FRACTURES OF CARTILAGE FOUND AT OPERATION

Type of Tear	Internal	External	Total	Percentage
Complete.....	356	41	397	48
Posterior......	182	69	251	31
Anterior......	112	31	143	21
Total.......	650	141	791	100

Space will not permit of more than a brief note of the end results, but there is general agreement that the results of operation are good. The knee is restored to normal. The one danger is septic infection, but with due care of detail, and a perfect technique, this is minimal. The technique necessary in order that bone and joint surgery may be safe, must reach a high standard, and does call for special training. The repair of a lateral ligament and still more of a crucial ligament tear is a highly specialized surgical procedure. Repair of a

lateral ligament is seldom called for as the tear is frequently incomplete and will repair naturally if given the necessary protection. A completely ruptured crucial is a serious disability, the results of operative repair are poor, and it is unlikely that the knee will be stable enough to stand up to hard manual work, or strenuous games.

SUMMARY

1. The differential diagnosis of injuries of the knee joint is discussed with particular reference to the difficulties of distinguishing between a rotation sprain and a torn semilunar cartilage, and also the differences between the primary and the recurrent derangement.

2. Treatment of the chronic sprain and the torn cartilage is contrasted. The operation for the removal of cartilage is briefly discussed, and postoperative treatment referred to.

3. An analysis of operation findings is made to show the relative frequency of lesions in various parts of the cartilage, that is the complete tear, the posterior tear and the anterior tear.

The relative frequency of injury to either cartilage is worked out for a series of 956 operation findings.

Habitual dislocation of the patella is seen in women. The first dislocation occurs in knock-kneed girls at about the age of puberty.

OPERATIVE TREATMENT OF GENU RECURVATUM

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GENU recurvatum, or hyperextension of the knee, is a deformity that causes little disability when it is of been directed toward strengthening the ligaments and muscles. The purpose of this paper is to focus attention upon a bony
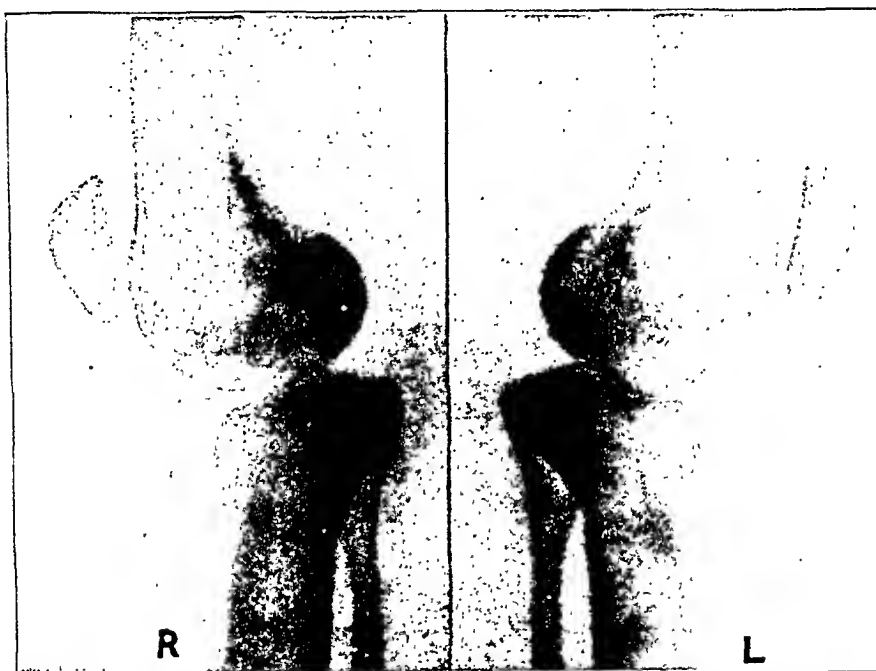
Fig. 1. Case 11. Bilateral genu recurvatum, showing the anatomic and structural downward sloping of the tibial surfaces and the forward position of the femoral condyles. (From Brett, in *J. Bone & Joint Surg.*, 17: 984, 1935.)

moderate degree. Such deformity may, in fact, be of advantage in helping to stabilize a paralytic leg in walking. Severe hyperextension, on the contrary, is a crippling deformity that makes locomotion difficult and necessitates the wearing of some type of support. Operative treatment is indicated for the correction of disabling genu recurvatum.

The pathology underlying genu recurvatum is generally recognized as existing in the weakness or paralysis of the musculature of the knee and in the stretching of the ligaments. Operative treatment of the deformity, therefore, has for the most part deformity of the anterior tibial or femoral surfaces as one of the underlying pathologic factors of genu recurvatum, and to describe an operative procedure for the correction of the deformity.

The causes of the acquired form of genu recurvatum are numerous and various. The deformity may occur as a sequel of diseases of the bones or joint, or as the result of disturbances of the muscular balance of the knee. It may be essential in origin, occurring from unequal growth of the epiphysis or diaphysis of the tibia or femur. It may occur in rickets or osteomalacia. Trauma, static disturbances, and finally, resection

of the knee as practiced in the treatment of the tuberculous joint, may be responsible factors.

Foremost among the underlying causes is infantile paralysis. Genu recurvatum may follow isolated paralysis of the quadriceps, or paralysis of the muscles on the posterior aspect of the joint. More often the origin lies in complete paralysis of the entire musculature of the knee. In paralytic genu recurvatum, the interference with the weight-bearing line, which is occasioned by the effort to prevent collapse of the knee, plays an important part in the development of deformity. A person with a paralyzed quadriceps, in walking, must lock the joint through pressure of the hand on the thigh, or through adaptation of other parts of the body. In either case, the posterior ligamentous apparatus of the joint is continually stretched, and a strain is thrown upon the anterior segments of the joint.

Less frequently, infection of the knee joint or of the tibia and femur may cause the deformity. In arthritis, osteomyelitis, and tuberculosis, the knee joint structures may be so extensively damaged that a genu recurvatum develops.

Trauma of the joint ends themselves, of the ligaments, or of the peripheral nerves is also an infrequent cause of hyperextension. Genu recurvatum may follow a fracture of the tibial or of the femoral shaft when healing takes place in such position that the line of weight-bearing is disturbed.

Still less frequent causes of the deformity are spastic cerebral paralysis and operative resection of the knee joint. In the latter case, too early weight-bearing following the operation is undoubtedly responsible for the development of the deformity.

In all circumstances, the disturbance of the line of weight-bearing is a factor that contributes to the development of hyperextension of the knee. When the body mechanics are deranged, a strain is thrown upon the joint structures, with a consequent alteration of the articular relations.

In a series of cases of genu recurvatum of various origins, the writer has observed

that the anterior surface of the tibia sloped downward. An arrest of growth in the diaphysis had undoubtedly caused the de-

Fig. 2. Case ii. A, knees held in the straight position through great muscular effort. B, knees in hyperextension—the only position in which the knees lock. (From Brett, in *J. Bone & Joint Surg.*, 17: 984, 1935.)

formity, since in x-ray studies the epiphysis appeared to be normal. To a great extent, such lack of growth may be explained by a disturbance of statics, that is, the deviation of the weight-bearing line. In paralyzed limbs; or in the presence of deformities of the hip or foot, such as toe-drop; or following trauma or infection of the knee joint, the anterior diaphyseal surface may be subject to unequal pressure. In one of the writer's cases, the tibial surfaces were sloped as the result of continuous hyperextension of the extremities, while the patient was lying on a frame with spinal disease. (Fig. 1.)

In the writer's experience, this downward inclination of the tibial surface is not always demonstrable in the x-ray examination, because of the fact that the curved weight-bearing surfaces of the femur wear into, or depress, the menisci of the tibia. Therefore, due to the transposition of the lateral marginal rim of the tibia, which is not affected by the curved weight-bearing surfaces of the femur, the corresponding

depressed and downward sloping surface may not show in x-ray studies.

The downward inclination of the anterior narily, the retroversion and inclination of the tibial head decrease with growth, so that by the age of ten the tibial weight-
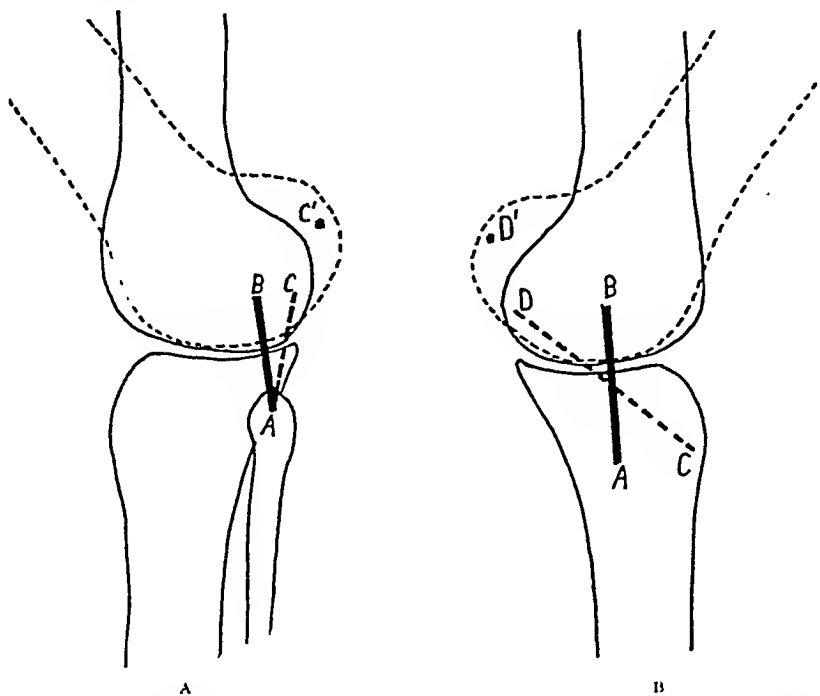
FIG. 3. A, showing the newly-constructed external band (A-C). A-B represents the normal external lateral ligament. C' represents the attachment C with the knee in recurvatum, which would be impossible if the band holds. B, showing the newly-constructed internal band (C-D). A-B represents the internal lateral ligament. D' represents the attachment D with the knee in recurvatum, which would be impossible if the band holds. (From Heyman, in *J. Bone & Joint Surg.*, 6: 689, 1924.)

Suture of all four edges of Fascia lata and Periosteum behind Femur
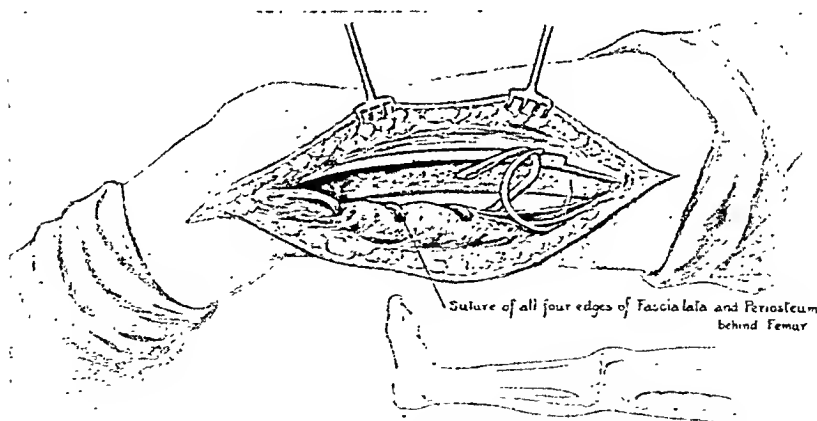
FIG. 4. Showing the formation of the check ligament. (From Gill, in *J. Bone & Joint Surg.*, 13: 49, 1931.)

tibial surface has been studied considerably from an ontogenetic standpoint. It is noted in connection with backward inclination of the tibial head in the fetus, in the infant, in the child, and even in the adult. Ordi-

bearing surface is level (Böhm). On the other hand, a person may inherit a predisposition to deformity in the extremity, with the result that there may be a lack of development. In such cases the retrover-

sion and the sloping surface of the tibia persist, and a genu recurvatum develops.

A slight downward sloping of the tibial

FIG. 5. Showing the insertion of the patella into the cavity on the tibia. (From Campbell, in *Ann. Surg.*, 96: 1055, 1932.)

surface, which is not uncommon in a normal adult knee, is not incompatible with good function, for in such cases the hyperextension is slight. On the other hand, when the sloping is marked, a great muscular effort is required to fix the joint surface in extension of 180 degrees. (Fig. 2.) The joint cannot lock when the forward part of the tibia is markedly sloped and when the femoral condyles project over the tibial surface. A person with such deformity is disabled, even when there is no apparent impairment of the muscular development or balance.

TREATMENT

The treatment of the hyperextended knee is concerned chiefly with the paralytic variety, since this is the common type. The early forms of treatment consisted of apparatus, arthrodesis of the knee joint, and supracondylar osteotomy. Operative methods were then devised to limit hyperextension by tendon transplantations and by strengthening the ligamentous apparatus. The tendon operations, which were met with a great deal of enthusiasm at the time of their introduction, have a limited appli-

cation at the present time. A tendon transplantation may be successfully carried out in mild paralysis of the quadriceps, pro-
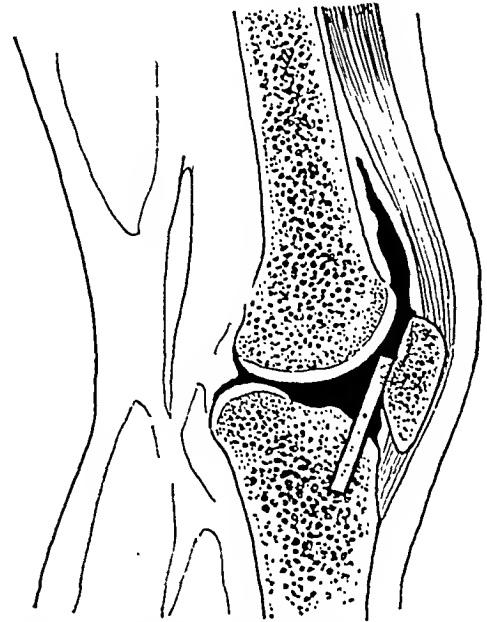
FIG. 6. Showing implantation of the bone graft. (From Mayer, in *J. Bone & Joint Surg.*, 12: 845, 1930.)

vided no severe deformity is present. When the hyperextension is of moderate or severe degree, tendon operations cannot be considered entirely satisfactory.

Several cases of successful limitation of hyperextension by the creation of check-ligaments have been reported. Heyman and Colonna constructed ligaments from the fascia lata of the thigh. Heyman constructed two lateral ligaments and secured them as far back as possible on the femoral condyles. (Fig. 3.) Colonna fastened one end of a rolled strip of fascia to the head of the fibula, carried the band through the shaft of the femur, and inserted it on the tibia. Gill successfully strengthened the posterior structures of the knee by creating a ligament from the posterior portion of the periosteum of the femur and fascia lata. (Fig. 4.)

When such constructed ligaments were found to stretch out gradually, surgical procedures on the bones were attempted. Wollenberg (1912) seems to have been the first to construct a bone block to check the motion of the knee. His operation consisted of removing a fragment of bone from

the anterior surface of the tibia and lifting it up to form a butt against the lower femur. Operations in which the patella was

raised to form a right angle with the tibial shaft. Only when this surface is level will the joint lock with stability. Following the
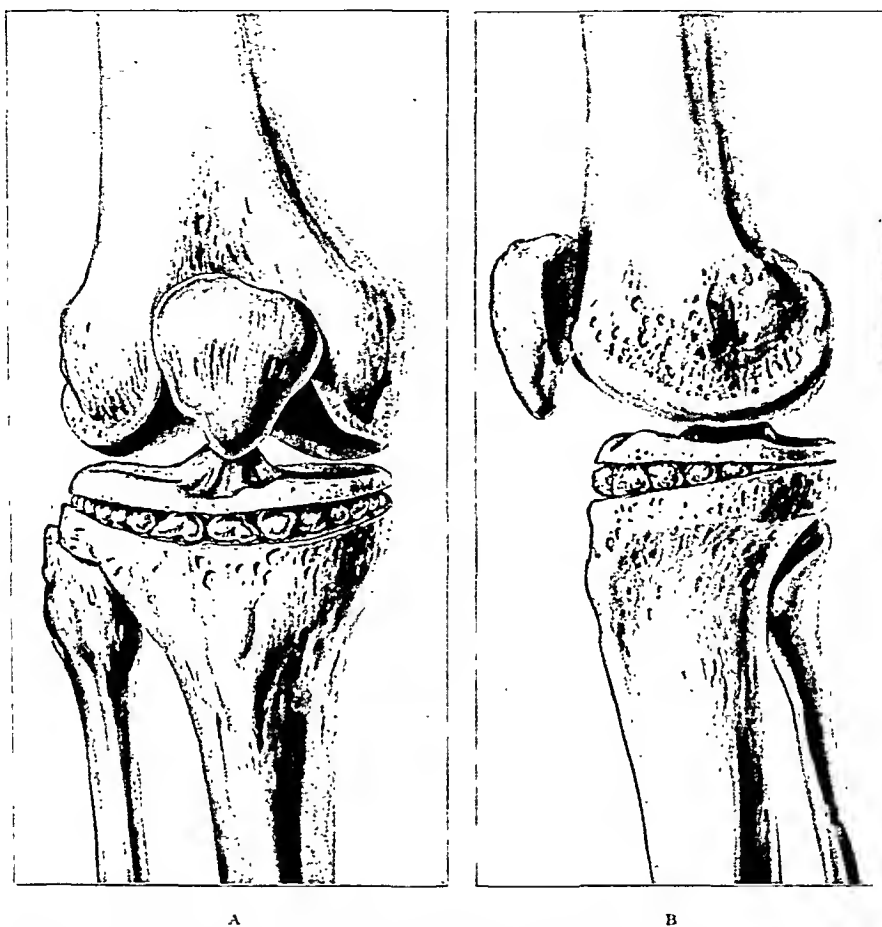
FIG. 7. A, anteroposterior view of elevation of the tibial joint surface with bone chips introduced in the wedge-shaped gap. B, lateral view showing the posterior hinge. (From Brett, in *J. Bone & Joint Surg.*, 17: 984, 1935.)

used as a buttress against stretching of the knee were next devised. Campbell fused the lower end of the patella to the anterior aspect of the tibia. (Fig. 5.) Modifications of this operation have been carried out by Mayer and by Tavernier and Guilleminet. Mayer drives a bone graft, which has been removed from the tibia or the femur, into the upper tibial surface, and fuses the protruding end with the denuded patella. (Fig. 6.)

Mechanically, these operations do not meet the problem of correction when deformity of the joint surfaces is present. When the anterior weight-bearing surface of the tibia slopes downward, it must be

operative correction, the ligaments and capsule, being relieved from mechanical strain, recover a certain amount of stability.

Operative adjustment of the tibial surface is also applicable in genu recurvatum when the deformity lies in the lower end of the femoral surface. In these cases, the anterior surface of the tibia is lifted up until it is on a plane corresponding with that of the flattened femoral condyles.

Two operations, which have for their object the raising of the tibial surface, have been reported in medical literature. Ciminata, in 1924, carried out this procedure in a case of genu recurvatum following osteomyelitis of the lower femur, in which the

anterior part of the tibial epiphysis had been damaged. Lexer carried out the procedure in a flail knee with genu recurvatum.
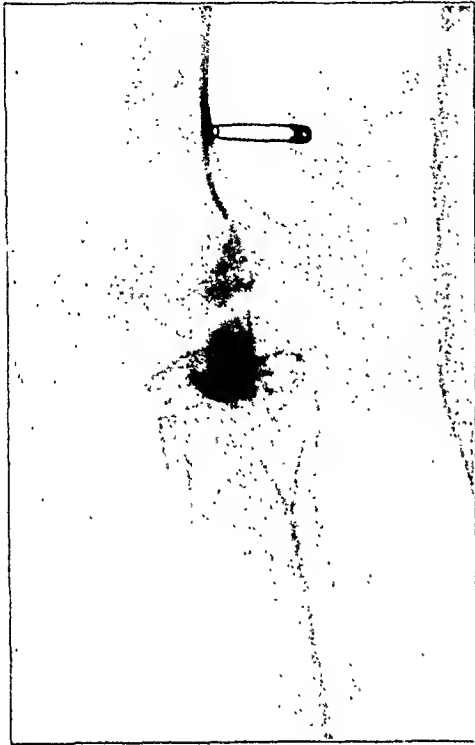
FIG. 8. Case 1. Roentgenogram taken two months after the operation, showing the posterior hinge and the elevation of the anterior tibial surface. (From Brett, in *J. Bone & Joint Surg.*, 17: 984, 1935.)

WRITER'S OPERATIVE TECHNIQUE

Prerequisites of the operation are lateral stability of the knee joint and adult bony growth.

The knee is bent to the right angle. The skin incision, curved in outline, begins just above the inner condyle; crosses the patellar tendon, without cutting it, just above the tibial tubercle; and ends at a point on the external condyle opposite the starting point. The flap of skin is dissected upward.

Two incisions are made, one on each side of the patellar tendon and running parallel to it. It is then possible to retract the tendon.

An incomplete osteotomy of the tibia is carried out just below the capsular attachment. Care is taken to cut the cortex along the front and sides of the tibia. The forward surface of the tibia is raised up, and the

posterior cortical surface is left to act as a hinge. The gap thus created is filled with bone chips, or with bone chips and beef
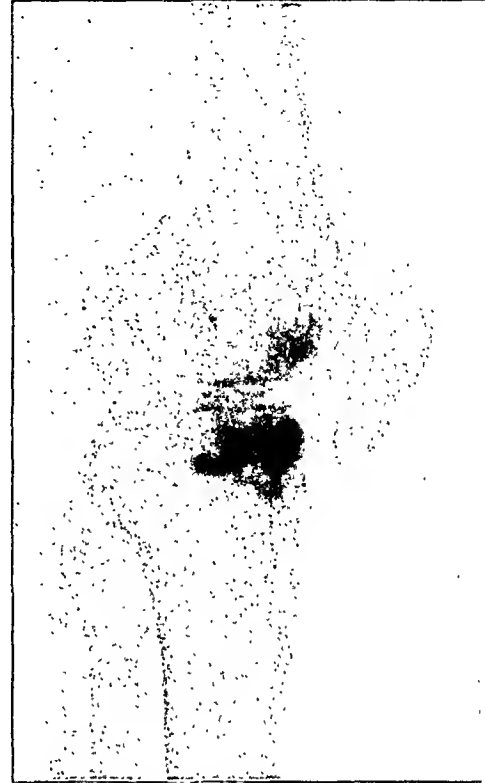
FIG. 9. Case 1. Roentgenogram taken one year after the operation, with the knee extended normally and in weight-bearing position. (From Brett, in *J. Bone & Joint Surg.*, 17: 984, 1935.)

bone screws in case there is a scarcity of autogenous material.

The wound is closed in layers. A plaster of Paris cast, extending from the toes to the groin, is applied with the knee in extension of 180 degrees or in slight flexion.

Six weeks after the operation, the cast is removed and a posterior plaster shell is applied, which is worn for two weeks longer. Baking and massage are begun when the cast is removed.

CASE REPORTS

This operation has been carried out in six cases. In one case, both tibial surfaces were elevated.

CASE 1.   A. D., a woman aged 34, complained of constant pain, weakness, and backward bending of her right knee. She walked with the aid of crutches for fear of falling.

At the age of 12, she had suffered a severe attack of infantile paralysis that had resulted in permanent paralysis of the muscles of the back, of the feet, and of the hamstrings and quadriceps of the right leg. She had been treated continually during the twenty-one years before the writer saw her for the first time. Both feet had been arthrodesed successfully.

Upon examination, the knee joint was found to hyperextend 30 degrees under weight-bearing. In the x-ray examination, a downward inclination of the forward surface of the tibia, as well as a cupping out of the upper tibial surface, was seen. The surfaces of the femoral condyles were flattened.

On May 25, 1934, operative correction was carried out according to the technique that has been described. (Fig. 8.)

In May, 1938, four years after the operation, the result was satisfactory. There was no hyperextension upon weight-bearing, and the knee locked firmly. The joint was not painful. Slight power had returned in the quadriceps. The patient was working as a clerk in a store. (Fig. 9.)

CASE II.   D. C. at the age of 15 was treated for a spinal lesion. For six months she was strapped to a frame, with two straps being fixed over the knees. The patient reported that these straps slipped below the knees. After this treatment, the patient had difficulty in walking, and the knees were painful.

Eight years later she consulted the writer, complaining of painful knees and difficulty in walking. The knees seemed to be protruding more and more.

Upon examination, the patellae were found to be prominent, and both legs hyperextended about 30 degrees on the femora. Both the tibiae and femora had a great deal of lateral mobility. (Fig. 1.)

On January 31, 1936, the tibial surface of the right leg was raised operatively according to the technique that has been described. On April 1, 1936, the operation was carried out on the left tibia.

In September 1938, two and a half years after the second operation, examination showed that the patient had obtained excellent results. There was neither hyperextension nor pain, and she walked well.

CONCLUSIONS

In mild cases of genu recurvatum, tendon and fascial transplants may be used successfully, but when there is a mechanical strain and when the use of the affected member is unrestricted, these tissues tend to stretch out gradually under the strain of weight-bearing. It has been the writer's experience that most cases of disabling genu recurvatum require some bony adjustment in order to stabilize the knee permanently for the weight-bearing that is demanded of the joint over a period of years.

Attention is called to the downward inclination of the anterior surface of the tibia as a common origin of genu recurvatum. Such deformity is the result of an arrest of growth in the tibial diaphysis, due to a combination of disturbed body mechanics and disease or trauma.

An operative procedure for the correction of the sloping tibial surface is described. This procedure has been carried out successfully in six cases.

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RECONSTRUCTION OF THE LIGAMENTS OF THE KNEE

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SINCE the game of football has evolved into one of the nation's major sports the treatment of injuries of the knee joint has become a very important problem, and there has been a material increase in the number of those requiring surgical treatment. The most frequent cause of disability undoubtedly results from trauma to the medial semilunar cartilage. However, rupture of one or more of the ligaments of the knee is often associated with cartilage injury and at times occurs independently.

There are only two ligaments in which rupture is of frequent occurrence, the internal lateral ligament and the anterior cruciate ligament, and in some instances both may be ruptured. These ligaments are commonly ruptured by the same mechanism which injures the medial cartilage, that is, sudden flexion with abduction and external rotation of the tibia on the femur. The anterior cruciate is also commonly injured by sudden hyperextension of the knee with the foot fixed, as in stepping into a hole in the ground, or being tackled on the anterior surface of the leg when the foot is fixed on the ground.

Ruptures of the external lateral and posterior cruciate ligaments are rare, and are usually brought about by a mechanism which is opposite to that causing trauma to the medial cartilage, namely, sudden flexion with adduction and internal rotation of the tibia on the femur; such a mechanism is obviously of rare occurrence.

Severance of both the cruciate ligaments, or of all four of the ligaments of the knee, may occur in the more severe dislocations, usually resulting from twisting and shearing forces.

A great many of these patients present themselves to the surgeon complaining of symptoms which are due to injury of the medial semilunar cartilage, and unless care is exercised an associated ligamentous injury may be overlooked, even at operation for removal of the cartilage. This undoubtedly accounts for many of those cases in which symptoms persist after excision of the injured cartilage.

The most outstanding single symptom of ligamentous rupture is a sense of "giving away," and this may or may not be associated with the classical symptoms of cartilage injury. Pain and effusion, which are also common complaints, result from the continued abuse of the abnormally relaxed joint.

Apparent impairment of the internal and external lateral ligaments is frequently observed after depressed fractures of the tibial condyles. These fractures do cause instability, which is entirely due to loss in continuity of bone and not to severance of the ligaments. Correction of this condition may be secured by an osteotomy with the transplanttaion of a wedge of bone on the depressed side after restoration of the anatomic alignment by elevating the tibial plateau to the normal plane.

Rupture or relaxation of the internal and external lateral ligaments of the knee is brought out in routine examination with the knee fully extended if the ankle is grasped with the right hand and the thigh fixed with the left. A lateral rocking motion of the leg by the right hand will reveal free abduction of the leg on the thigh if the internal lateral ligament is ruptured or elongated; while if the external lateral ligament is ruptured or relaxed adduction of the leg will be elicited. Examination of the opposite knee should always be made for comparison, as there are cer-

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tain loose jointed individuals in whom undue motion is present.

If the anterior cruciate ligament is sate quite well by increased tonicity of the muscles crossing the knee joint. However, in all young, active people and especially in
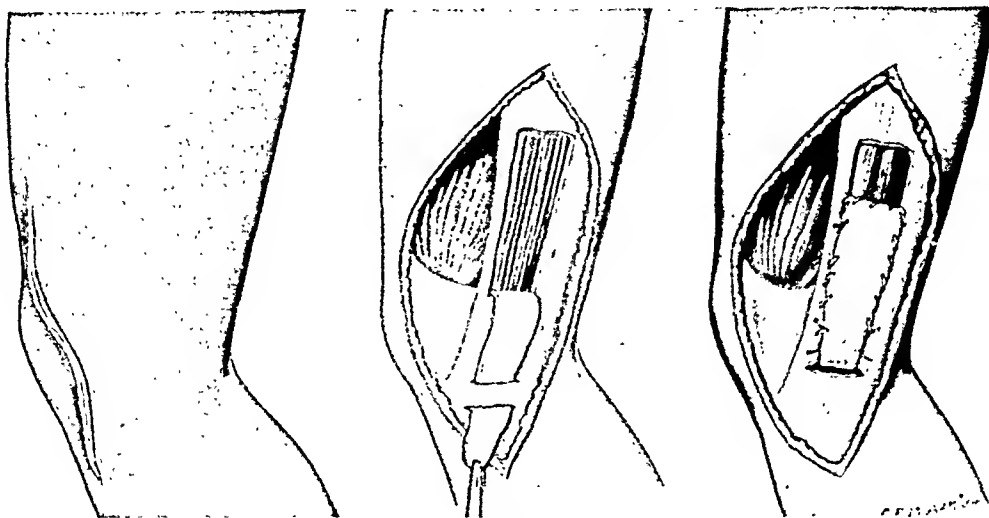
FIG. 1.   FIG. 2.   FIG. 3.

FIG. 1. Internal incision parallel to the patellar tendon, which gives access to the joint and internal lateral ligament.

FIG. 2. Dissection of the flap, which is passed through a tunnel in the soft tissues over the internal condyle of the tibia, 1 inch distal to the joint.

FIG. 3. Flap drawn taut through the tunnel and stitched in place.

elongated or ruptured the tibia can be made to glide forward on the condyles of the femur when the knee is flexed, and to some extent in full extension. Frequently the excursion will be as much as 1 inch. In all cases of complete rupture this test is definitely positive.

In impairment of the posterior cruciate ligament the tibia will glide backward on the femur when the knee is flexed; and when both ligaments are severed, as in complete dislocation and after severe torsion force, the tibia can be made to move backward and forward on the femur with great freedom. However, in most acute injuries of this type there is so much reaction in the joint and periarticular structures, with the subsequent formation of fibrous tissue, that a functionally stable knee usually follows conservative measures.

Only a very small percentage of cases of internal derangement of the knee joint shows sufficient evidence of ligamentous impairment to warrant operative procedures for the repair of these structures. Indeed many inactive individuals compen-

athletes, and those whose occupations require strenuous labor, early repair of ligamentous ruptures is urgent, since excessive use of unstable knee joints usually results in damage to the semilunar cartilages and development of typical local osteoarthritis that impairs the results of any subsequent operation.

Operations for repair of the ligaments of the knee are indicated only in patients with continued disability and increasing symptoms which are obviously the result of ligamentous instability. In carefully selected cases, any of the more modern operative procedures will give uniformly excellent results, and even in long neglected cases the end results are usually gratifying.

Repair of the Internal Lateral Ligament. There are many operations for repair of the internal lateral ligament of the knee, but the author has had personal experience with only three of these measures, his own technique and the procedures described by Edwards and Mauck.

The Author's Technique. A skin incision is made on the anteromedial aspect of the

knee parallel with the quadriceps tendon, the patella and patellar tendon, beginning 2 or 3 inches above the patella and extend-

tissues on the medial condyle of the tibia are not sufficiently strong to withstand considerable tension, the strip of fascia
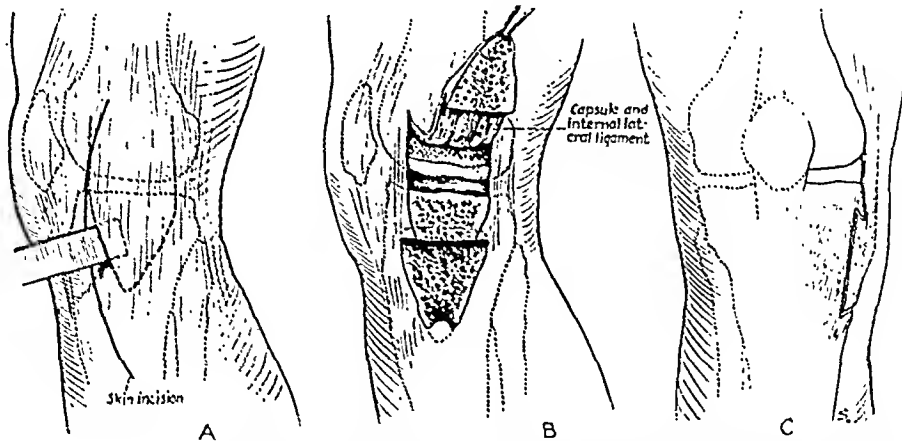
Fig. 4. Mauck operation. After elevation of the internal lateral ligament with its bony attachment, the fascial bone flap is drawn distally as far as possible and anchored beneath a groove in the internal condyle of the tibia.

ing just below the tibial tubercle. The anterior flap of the skin incision is dissected up and a small incision is made into the knee joint. The joint is carefully inspected and the cartilage is removed if internal derangement exists.

To repair the ligament, a strip of deep fascia, ½ inch wide and 4 inches long, is dissected from the inner aspect of the knee from above downward to a point opposite the center of the internal condyle of the femur. An incision 1 inch in length is then made through the lower portion of the deep fascia and periosteum down to the bone, 1 inch below the upper extremity of the tibia, parallel with the line of the joint. Parallel to this incision and 1 inch lower over the tibia, an incision of equal length is made. A hemostat is passed through the lower incision close to the bone and brought out through the upper incision. The free end of the fascial flap is grasped with the hemostat and drawn through the tunnel in the dense fascia and periosteum. With the knee at 150 degrees and the leg force-fully adducted on the thigh, the fascial flap is drawn tight and stitched as high as possible to the margin of the fascia from which it has been dissected. This provides an adequate pulley action and reëstablishes a tight internal lateral ligament. If the

lata may be passed through a tunnel in the bone and sutured to itself.

In some individuals, the fascia on the inner side of the thigh is not well developed and not sufficiently strong for this procedure; in which event, another procedure, such as the Mauck or Edwards operation, is preferable. This, however, occurs very rarely, since a great majority of patients coming to operation are young and vigorous.

Very few minutes are required for the completion of this extremely simple procedure. Postoperative reaction is minimal, and the period of convalescence is definitely shortened.

This operation has been done seven times, and a good result obtained in all cases. However, in two cases the operation was done in connection with osteotomy of the tibia, and the author feels that the osteotomy was responsible for the good results in these cases.

Technique (Mauck). A slightly curved incision, its convexity anteriorly, is made on the medial aspect of the knee from the adductor tubercle of the femur to 4 inches below the articular surface of the tibia. The distal attachment of the internal lateral ligament is removed with a triangular section of bone 2 inches long and ½ inch

wide at its proximal end. At the joint surface, the capsule is split upward for 1 inch at both the anterior and posterior margins
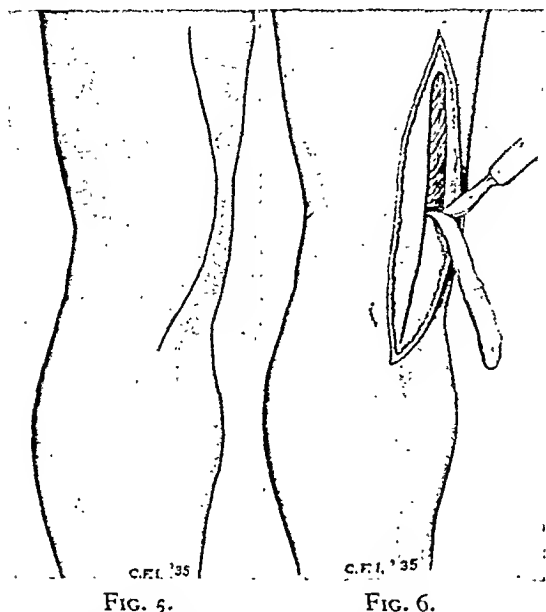
FIG. 5.   FIG. 6.
FIG. 5. Long medial incision for exposure of the anterior compartment of the knee joint.
FIG. 6. Dissection of a strip from the tendon and capsule.

of the bone flap, providing ample exposure for removal of the internal semilunar cartilage, if necessary, or the correction of any other internal derangement. The ligament and bone flap are drawn downward, and the point to which the articular edge of the flap reaches is marked by a chisel cut. At this point, a notch is made in the side of the tibia, forming an overhanging shelf of bone under which the lower end of the bone flap is morticed. The inner surface of the ligament is scarified and placed in contact with the denuded area of the tibia, that the ligament may be firmly adherent to the bone when healing is complete.

This is a very simple and ingenious procedure, which the author has employed in several cases, all of which are too early to be of any benefit in evaluating the procedure.

Technique (Edwards). A straight incision is made on the medial aspect of the knee, exposing the sartorius muscle from the lower end of its fleshy belly to the tendon close to its insertion. The saphenous nerve, which lies along the medial side of the sartorius muscle should not be injured. By blunt dissection, the tendons of the gracilis and semitendinous muscles are exposed, severed at their musculotendinous junctions, and drawn forward. A groove is made on the internal condyle of the femur at the point of normal attachment to the ligament, and the tendons are fixed in this groove with a staple. The proximal ends of the gracilis and semitendinous tendons are sutured to the sartorius to conserve their contractive function.

The author has employed the operation for repair of the internal lateral ligament only twice; one of these cases could not be followed while the other obtained an excellent result, though there was some atrophy of the thigh at the end of two years. This is a rather extensive procedure, and therefore should be reserved for rare instances when failure from less serious procedures occurs.

Repair of the External Lateral Ligament. Rupture of the external lateral ligament is extremely rare and most of the techniques described for repair of the internal lateral ligament are readily adaptable to the external ligament also.

The author's technique is even more applicable to the external lateral ligament in that the fascia lata on the outer aspect of the thigh has greater tensile strength.

Edwards has described an excellent procedure for the repair of the external lateral ligament, in which he turns down a strip of fascia lata, attaching it to the head of the fibula, and reinforces this with a strip of the biceps tendon which is fixed to the lateral femoral condyle.

Repair of the Cruciate Ligaments. Rupture of the cruciate ligaments is of rare occurrence as compared with the other internal derangements of the knee, and in almost 100 per cent of cases the disability is due to rupture of the anterior cruciate ligament.

The Anterior Cruciate Ligament. The author formerly employed the technique
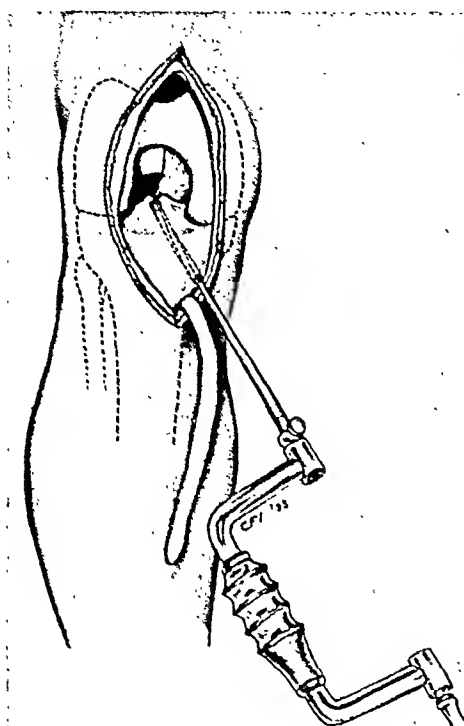
FIG. 7. Reaming of a tunnel through the internal tuberosity of the tibia in line with the normal direction of the anterior crucial ligament.
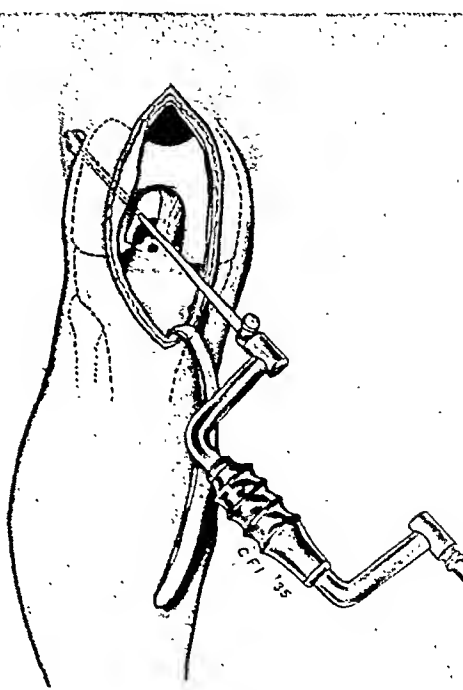
FIG. 8. Drilling of a tunnel in the external condyle of the femur in line with the direction of the anterior crucial ligament.
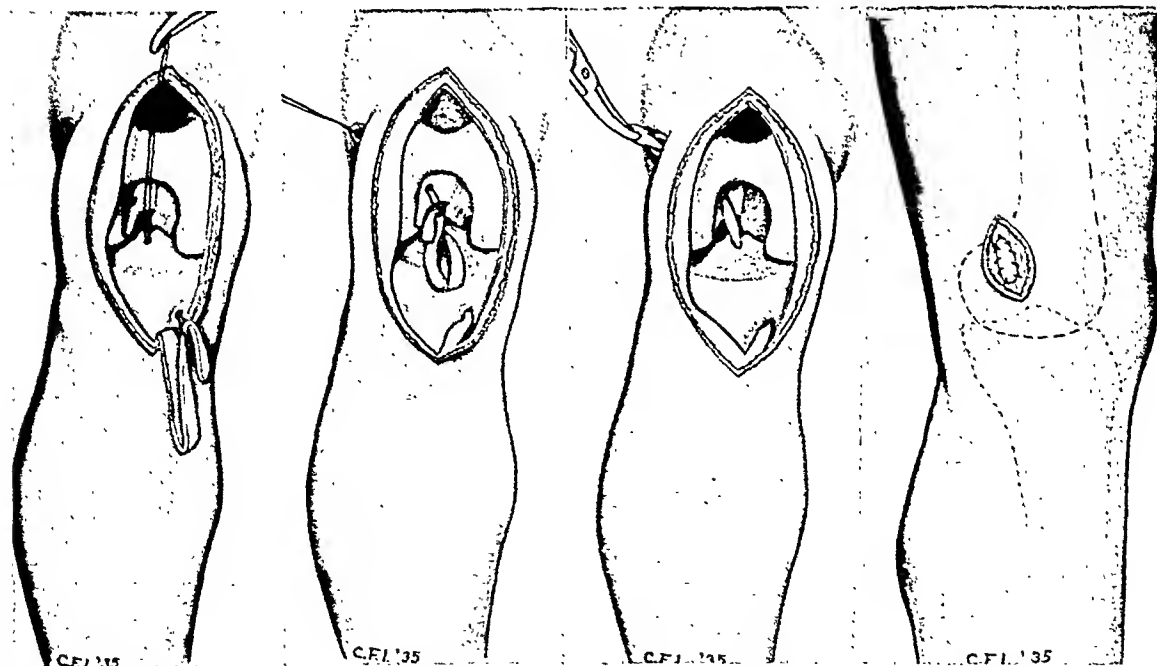
FIG. 9.   FIG. 10.   FIG. 11.   FIG. 12.

FIG. 9. Insertion of a wire loop through the tunnel in the tibia, and engagement of the end of the strip.

FIG. 10. New ligament drawn through the tunnel in the tibia.

FIG. 11. New ligament passed through the tunnel in the external condyle of the femur and drawn taut with the knee flexed to 140 degrees.

FIG. 12. Attachment of the superior extension of the ligament to the periosteum and fascia lata.

of Hey-Groves for replacement of the anterior cruciate ligament, having used this procedure in eight cases prior to 1935,

joint inspected; the cartilage is excised, if impaired. The anterior cruciate ligament is repaired by dissecting a long pedicle strip
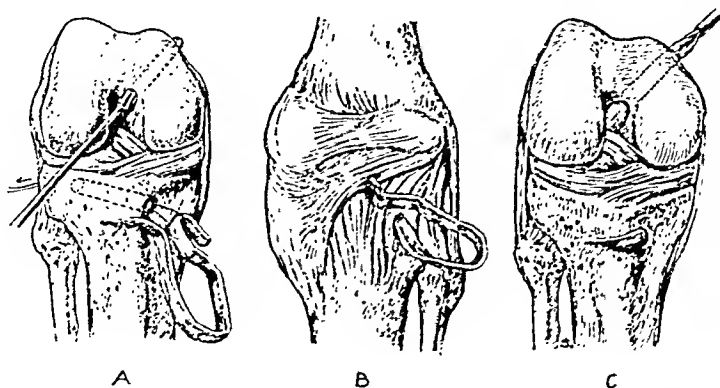
FIG. 13. Repair of posterior cruciate ligament: A, new ligament drawn through tunnel in the tibia; B, thence through the posterior capsule; C, fascial strip passed through tunnel in internal condyle of the femur and anchored to internal lateral ligament.

with excellent end results in five cases, and failure in two due to subsequent rupture of the new ligament, while one case could not be followed.

This operation requires a long J-incision over the lateral aspect of the thigh and anterior aspect of the knee, and it was the marked postoperative reaction and prolonged convalescence of these eight cases that prompted the author to devise a short, simple procedure, which he has used in fourteen cases since 1935. Nine of these were followed for one year or more with good results in seven and failures in two; the other five either are too recent or could not be followed.

The author's technique for restoration of the anterior cruciate ligament is on the same mechanical principle of other procedures, but can be accomplished with much less surgery to the knee joint and consequently is followed by less postoperative reaction and a shorter period of convalescence.

Technique. A longitudinal curved incision about 6 inches in length is made parallel with the quadriceps tendon, the patella, and the patellar tendon, for complete exposure of the knee joint. Dissection is made into the joint cavity throughout the entire incision and the interior of the

of fascia, capsule and tendon, from the lateral edge of the incision about ⅓ inch in diameter and 8 inches in length. Dissection of the strip is made downward to the attachment of the capsule to the tibia. This strip contains very strong tendinous tissue from the medial border of the quadriceps and patellar tendons. A 6 mm. drill hole is then made from a point on the anterior internal surface of the inner tuberosity of the tibia about 1½ inches below the joint, and emerges in the joint at the normal lower attachment of the anterior crucial ligament just anterior to the spine of the tibia. The same drill is then inserted into the intercondylar notch through the posterior portion of the external condyle of the femur, emerging under the skin above and posterior to the external condyle. A 3 inch incision is then made over the point of the drill with dissection down to the bone at this point. A Macey carrier or rustless steel wire loop is passed from above downward through the drill hole in each bone and the end of the pedunculated flap brought through to the superior exit of the tunnel in the external condyle of the femur. The flap is now drawn very taut with the knee in about 140 degrees flexion. About 3 inches of the strip should extend beyond the

tunnel and this is stitched to the periosteum and fascia lata. Both wounds are now closed in routine manner and a posterior splint applied with the knee in 140 degrees flexion. The ligament replaces anatomically the anterior crucial ligament, and there should be no undue anterior gliding of the tibia when the ligament is attached above.

This procedure can be carried out quickly, and when desirable, can be combined with the author's operation for repair of the internal lateral ligament.

The Posterior Cruciate Ligament. Repair of the posterior cruciate ligament has usually been carried out by the Gallie or Cubbins technique. However, these procedures call for very extensive surgery and because of this the author's method for repair of the anterior cruciate ligament has been modified by one of his associates, Dr. Hugh Smith, so as to be suitable for reconstruction of the posterior cruciate ligament. This operation has been carried out only on cadavers, but the technique is simple and necessitates a minimal amount of surgery.

In this procedure a segment of the quadriceps and patellar tendons and capsule 8 inches long is dissected down, as in the operation for repair of the anterior cruciate ligament. A ¼ inch drill is passed through the tibia just below the articular surface, from its anteromedial to its posterolateral aspect, and the drill point exposed by blunt dissection through a posterolateral incision. The strip of tendon is drawn through the tibia and its free end pushed through the posterior capsule at the normal attachment of the ligament into the anterior compartment of the knee. A drill hole is then made though the medial femoral condyle at the normal anterior attachment of the posterior cruciate ligament and the free end of the new ligament is drawn through and sutured to the upper border of the internal lateral ligament through a third small incision.

Anterior and Posterior Cruciate Ligaments. Combined repair of the anterior and posterior cruciate ligaments may be carried out by the technique described by Gallie or Cubbins. However, such extensive surgery is seldom indicated or advisable.

Repair of Lateral and Cruciate Ligaments. Combined repair of the internal lateral and anterior cruciate ligament is at times indicated and desirable.

Alwyn Smith modified the Hey-Groves operation by dissecting down a longer strip of fascia lata than was necessary to replace the anterior cruciate ligament and reflecting the redundant portion upward on the medial aspect of the knee to form a new internal lateral ligament.

The two operations devised by the author for the repair of the anterior cruciate and the internal lateral ligament form a very satisfactory combined procedure, as they can be done quickly and with less postoperative reaction than operations requiring long strips of fascia lata from the same limb.

While it is not pertinent to this discussion it may be well to mention that repair of acute rupture of the ligaments of the knee may be carried out with success, although this procedure is seldom indicated as conservative measures are usually sufficient. The author has had occasion to repair acute ruptures of the ligaments of the knee, although in most of these, open operation was done primarily for some other condition, the severed ligaments being repaired at the time.

DISCUSSION

At the recent meeting of the Southern Medical Association the author reported an end result study of twenty-two cases in which complete replacement of the anterior cruciate ligament was done (*Southern Medical Journal* has details of this study).

The present discussion comprises thirty-nine operations for reconstruction of the ligaments of the knee. In twenty-two of these the anterior cruciate ligament has been replaced, while in seventeen the internal lateral ligament has been repaired. Eight of these have been done during the

past year and must be excluded, while adequate follow-up is not available in five. Three other cases are excluded from the study because of inability to classify them, leaving a total of twenty-three cases followed over a period of from one to nine years.

All of the thirty-nine cases were males between the ages of 18 and 45, only five having been 26 years or older. The average age of the group was 23.2 years. Twenty-eight were athletes or had received their original injury in athletics. The average duration of symptoms prior to operation was 34.2 months, the extremes having been six months and twenty years. The medial semilunar cartilage was removed twenty-seven times, and had been removed previously in two others. The lateral cartilage was excised in one instance. Of the twenty-three followed cases, nineteen have good results, while four are failures.

This study of thirty-nine operations for reconstruction of the ligaments of the knee constitutes a relatively large series, since these procedures are not required frequently enough to make a great number of cases available from any single source. The good results achieved amply demonstrate the value of the procedures mentioned above in restoring young, active individuals to normal.

No attempt has been made to describe all operative methods for repair of the ligaments of the knee, but only those with which there has been personal experience.

In closing, the author would like to emphasize the fact that operations for reconstruction of the ligaments of the knee are very definitely indicated in young, active individuals having prolonged disability due to ligamentous rupture. In this group of cases nothing short of anatomic restoration of the ruptured ligament should ever be accepted.

CONCLUSIONS

1. Reconstruction of the ligaments of the knee is definitely indicated when disability persists following conservative treatment.

2. Nothing short of anatomic restoration should be accepted in young active individuals, particularly in athletes and laborers.

3. Simplified operations for reconstruction of each of the ligaments of the knee joint, herein described by the author, have been used in a relatively large number of cases with good results.

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CRUCIATE LIGAMENTS

A RÉSUMÉ OF OPERATIVE ATTACKS AND RESULTS OBTAINED

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IT is nine years since we performed our first operation for the reconstruction of the cruciate ligaments of the knee joint, in which we used a part of the fascia lata, following the method of Hey-Groves and Alwyn Smith for the anterior cruciate ligament, and also used the aponeurosis of the biceps femoris for the reconstruction of the posterior cruciate ligament.

Of three patients in whom this procedure was carried out, the results in two were excellent in that they were able to continue their labor with no looseness of motion and no weakness of the limb. One, in which there had been an oblique tear of the fibular collateral ligament in addition to an avulsion of the fibular head, did not have a stable joint. In this case we ascribed the failure to the serious injury to the collateral fibular ligament and to our failure to re-attach this collateral fibular ligament to the head of the fibula.

With the possibility being considered that the removal of the aponeurosis of the biceps had also weakened this muscle in such a manner that its stabilizing effect upon the joint was lost, this failure stimulated us to the second procedure (published in Surgery, Gynecology and Obstetrics, February 1, 1937), using the posterior portion of the fascia lata, bringing it up and around behind the head of the fibula and beneath the popliteus. The cases of the repair of the posterior cruciate by this method have been successful in that we have a 95 per cent stable knee, without

any excessive fluid being present. In those cases where there has been an injury of the anterior cruciate ligament seen early, operation has as a rule been performed under mistaken diagnosis of fractured dislocation of the medial meniscus. The ligament in these cases had slipped down to the lateral or medial side of the tibial spine, causing a distinct lock after the knee joint had been in flexion. If, at the time the patient was completely anesthetized, we had made careful tests as to the stability of this joint, the lesion could have been diagnosed before the joint was opened. These tests consist of pushing the flexed tibia forward and backward upon the condyles of the femur, then putting the limb in extension, and observing the degree of lateral motion present with the limb in this position. Another thing that can be done very satisfactorily to test the stability of the knee joint is to arrange the examining hands, while it is in extension, so that the tibia can be pushed laterally and medially, and the degree of free motion present under these circumstances observed. In some patients with marked muscular development, an assistant may help to stabilize the femur while the tibia is moved.

The abnormal movements of the plateau of the tibia upon the femoral condyles are very important and should always be elicited before any operation of the knee joint is made. There were two ruptures of the posterior cruciate in which misdiagnoses were made, due to this same error of

not testing the mobility of the tibia upon the femur. In each of these cases the ligament had been ruptured and dislocated

FIG. 1. Primary incision, beginning dissection of fascial strip from vastus lateralis and removal of aponeurosis from biceps femoris. Note width of fascial strips and points to which they are to be dissected. (From Cubbins et al. in Surg., Gynec. & Obst., 54: 299, 1932.)

down in between the lateral condyle and the plateau of the tibia. One anterior cruciate was found partially ruptured with a fractured dislocated medial meniscus, and the rupture in this anterior cruciate was in the middle portion so low that it was possible to repair it with silk sutures. This repair, with the removal of the fractured and dislocated medial meniscus, served to restore the knee joint to normal with no subsequent disability. Just recently we have had another rupture in the medial portion of the anterior cruciate without an injury to the meniscus. All the others have

apparently been torn from the femoral insertions.

In a patient who had had an operation
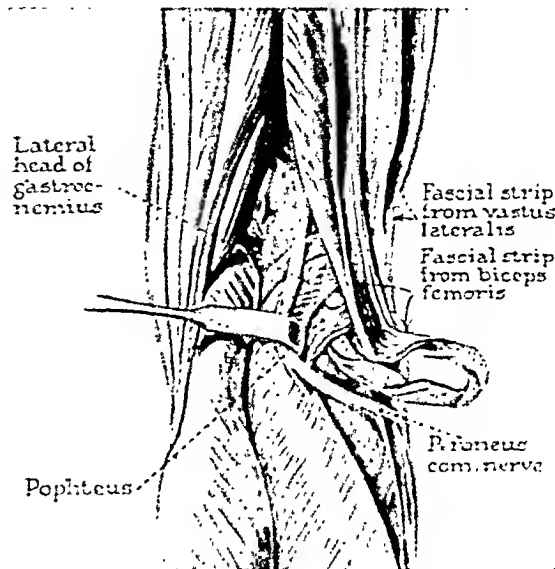
FIG. 2. Point at which the slightly twisted aponeurosis and tendon of the biceps are carried up beneath the popliteus and lateral to the outer head of the gastrocnemius and peroneus communis nerve. (From Cubbins, et al. in Surg., Gynec. & Obst., 54: 299, 1932.)

for a ruptured and dislocated medial meniscus five years prior to our inspection, we found a loose knee joint which locked so firmly that it was extremely difficult to free the locked joint, and this locking was due to the lateral displacement of the tibial plateau so that the spine of the tibia impinged upon the lateral condyle of the femur and locked the joint. This is the least successful of the cases where there has been a repair made of a single ligament, and the only reason we can give for the lack of success is the fact that the patient did not give the knee joint the proper rest, having danced at the end of four weeks following the operation. This activity, we are sure, served to stretch and injure the newly transplanted ligament.

As stated in our previous paper, we have had one case in which there was a compound complete dislocation of the tibial head, which was debrided, sutured loosely, and immobilized for 100 days, and still has, so far as clinical examinations can prove, a

perfectly normal joint. No excess motion can be obtained without an anesthetic, and up to the present time we have had no

Fig. 3. Alternative procedure by which both new cruciates may be obtained from the fascia lata. Observe carefully the points where the incisions end, as this is the origin of the new ligaments. (From Cubbins, et al. in *Surg., Gynec. & Obst.*, 64: 218, 1937.)

reason for giving this individual an anesthetic of any type.

We have had three cases of complete dislocation of the tibia upon the femur since our last report, which have been immobilized without an open operation. One of these was successful and had a stable knee; another had a flail joint at the end of 120 days of immobilization, and an operation for the reconstruction of both cruciate ligaments was performed, with an excellent result; one other case is still in immobilization and cannot be reported upon at this time. It is quite obvious that one case failing to have function reestablished following 120 days of immobilization is insufficient to draw a conclusion. It is true that all of the cases upon which we have operated have had varying degrees of immobilization, but the degree and the length of time the immobilization was continued

is in doubt. None of these cases that have been immobilized for 120 days has had a stiff joint. For that matter, a semi-rigid
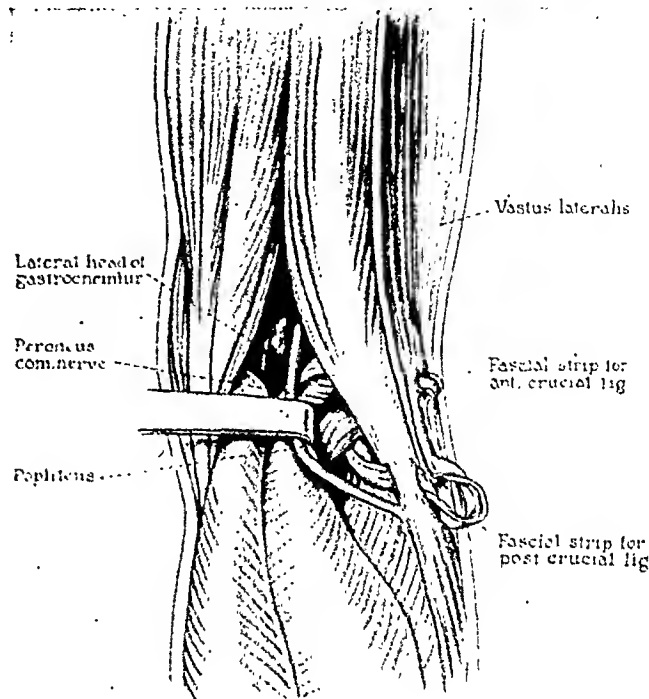
Fig. 4. The new posterior cruciate from the fascia lata being drawn in through the fascia over the head of the fibula, beneath the lateral head of the gastrocnemius-peroneal nerve and popliteus tendon. (From Cubbins, et al. in *Surg., Gynec. & Obst.*, 64: 218, 1937.)

joint would cause much less disability than a flail joint.

One of these completely dislocated knees was operated early, in order to determine the feasibility of such a procedure and the possibility of saving a long period of disability. However, on opening this knee joint we found that the collateral fibular ligament had been torn from the lateral condyle of the femur, the collateral tibial ligament had been torn from the medial condyle, and apparently the ligament of Winslow, or oblique popliteal ligament, had also been torn from its tibial attachment. While we succeeded in reconstructing the cruciates and getting these avulsed ligaments readjusted in such a manner that the individual at this time (six months following the operation) has a very good knee joint, we would not advise early repair of a completely dislocated knee joint in the future. Immobilization of these completely dislocated knee joints is strictly

indicated because no further operative repair may be required, and if subsequent operative work is needed it will not be

Fascial strips from vastus lateralis

End of new ant crucial lig anchored under periosteum
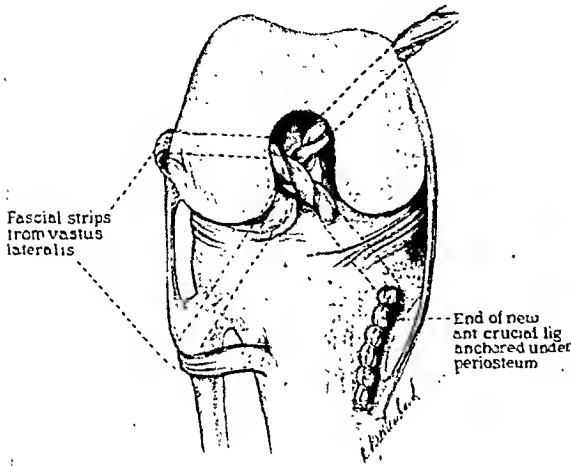
FIG. 5. Shows the ligaments pulled into position through the new openings and the anterior sutured into position with a continuous catgut stitch.

nearly so extensive as that in a newly dislocated joint.

Since we have been making exhaustive tests as to the stability of the knee in all operations where the individual is completely anesthetized, we have come to the conclusion that a great majority of injured menisci are caused in individuals with relatively loose knee joints, this looseness permitting the entrapment and injury of the meniscus. In order to determine this looseness, it must be quite obvious that both knees must be carefully tested. The motion of the flexed tibia upon the femur in these cases is about ¾ inch anteroposterior and postero-anterior, without any lateral motion in the extended limb. One patient operated upon showed a marked increase in the anteroposterior head of the tibia upon the femur, and when the knee joint was opened there was no evidence of any cruciate ligaments being present, although the injured boy gave no history of any previous accident of any kind. The removal of a fractured and dislocated meniscus was followed by a complete and uneventful recovery, which has been satisfactory for four years.

As a résumé, we have no hesitation in stating that an operation upon a knee joint, under local anesthesia, is contraindicated, on account of the inability to completely relax the great thigh muscles and consequently overlooking the possibility of an injured cruciate.

These newly transplanted cruciate ligaments live and function in a normal manner, being covered at an early period with synovial membrane. They should be made of the fascia lata ¾ to 1 inch in width, and firmly sutured into the bed following the transplantation. These sutures become firmly imbedded in fibrous tissue in the bony canal, and their point of insertion fuses in a new fibrous tissue that is almost normal in appearance. The transplanted ligament that goes up through the medial condyle of the femur is rapidly covered with a synovia that leaves no trace of its implantation.

In any operation upon the knee joint we must reëmphasize—first, the necessity of accurate determination of the amount of motion present of the tibial plateau upon the femoral condyle; second, that an adequate incision be made so that a careful and complete inspection of the knee joint can be made. The main reason for this large incision that at times in a fractured dislocated medial meniscus the joint is so firmly locked that even during anesthesia no abnormal mobility may be obtained. Our operative attacks are always carried out following careful tests to determine the coagulation and bleeding time, then a Martin band and a tourniquet are used, applied high on the thigh, so that we have a bloodless field, and if an injured cruciate is discovered after the joint has been opened, we have the materials at hand for its proper reconstruction. At the time the incisions are made, each point which shows a blood droplet is clamped and ligated with oo catgut. This will save a large amount of oozing, and up to the present time we have had no serious bleeding following any of these operative attacks done under a tourniquet. The limb is then covered with

voluminous dressing and immobilized for about thirty days, at an angle between 25 and 30 degrees, in order to avoid any strain upon the cruciates. At the end of thirty days it is fixed in a straight angle, with the idea that if it should be ankylosed it would be in the best possible position for service. This second position is retained for ninety additional days. In our cases, at the end of this period of immobilization there has remained a slight excess motion, which is steadily decreased with use. This decrease in motion in our opinion is due to the improved muscular tone.

CONCLUSIONS CONCERNING VALUE OF CRUCIATE LIGAMENT OPERATIONS

1. Early operation for repair of ligaments in a completely dislocated knee joint is contraindicated. The limb should be immobilized for at least 120 days. A certain percentage of these injured knees will recover without operation.

2. Early operation for the rupture of a single ligament is always indicated, and results are much better if the operation is performed at an early date.

3. Operative attack for those knees that have been completely dislocated and remain loose and flail-like following immobilization is strictly indicated, and with one exception those that we have repaired have had an efficiency of 90 per cent plus.

4. Transverse rupture of the collateral tibial and collateral fibular ligaments, either single or compound, is extremely rare without injury to both cruciate ligaments.

5. Avulsion of the femoral attachment of the collateral tibial and collateral fibular ligaments is very common, and recovers completely with immobilization of ninety days. Stiff joints are rare in this type of injury.

6. Regeneration of the cruciate ligaments following rupture or avulsion may not occur. In those cases of double cruciate rupture that have been repaired from three to twelve months following the injury, no trace of the ruptured ligaments has been present. This leaves a marked vacant space in the intercondylar notch. We are not in a position to state how frequently this failure to regenerate occurs.
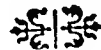
RUPTURES OF THE LATERAL LIGAMENTS OF THE KNEE JOINT

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THOSE who study traumatic lesions of the knee observe that lesions of the lateral ligaments are seldom found in the clinic. If they have seen patients with such lesions and wished to look for reports on this subject, they must have been surprised to find so few publications in this field. One factor is obviously related to the other.

Even very serious trauma rarely interferes with the lateral ligaments. A serious trauma of the knee joint, in order to produce lesions of the semilunar cartilages must overcome the strong resistance of the crucial ligaments, the capsule and its reinforcements, and the lateral ligaments, strengthened by the action of the muscular tone. We can therefore state that any injury which provokes a lesion of the lateral ligaments almost invariably affects at the same time in a greater or lesser degree, the capsule and the crucial ligaments.

Physiology. The lateral ligaments have their insertion in the femur in the upper part and in the tibia in the lower; they are tense in extension of the knee and lax in flexion due to the postero-anterior increase of the curve of the condyles. However, the external lateral ligament becomes tense in flexion if this is accompanied by external rotation. The internal lateral ligament, which is longer than the external, has only a small part of its fibers (in the short posterior portion) tense in flexion.

The lateral ligaments are oblique in an inverted sense; the inner one goes downwards and forwards, and the external one, downwards and backwards. This obliquity increases in external rotation and diminishes in internal rotation.

Physiology and Physiopathology. The special arrangement of the lateral ligaments explains why trauma to the extended knee which tends to separate the articular surfaces outwards or inwards, increasing the "valgus" or producing "varus," can cause rupture of the lateral ligament. Which ligament is affected depends upon the direction of the force. Furthermore, a forced rotation outwards with the knee extended may produce rupture of one or both ligaments.

Dislocations of the knee, especially outwards or inwards, produce among other lesions a rupture of the ligaments. Prolonged extension and some chronic arthritis with intra-articular collection may produce a lax joint.

In most of the observed cases the internal lateral ligament is the one injured; experimental studies on the cadaver likewise show that the internal ligament is the first and most frequently injured. Oudard calls the internal the ligament of the sprained knee. The uneven susceptibility to injury is partially explained by anatomic differences. The external lateral ligament is 5 or 6 cm. long, 3 to 6 mm. wide, and cylindrical in form, which makes it very resistant to trauma. The internal one is like a flat ribbon 10 to 12 cm. long and 12 to 15 mm. wide which makes it more liable to injuries. While the external ligament is separated from the capsule, the internal one is joined to it, having very close connections with the internal semilunar cartilage.

These anatomic characteristics and the lesser mobility of the external condyle which generally acts as an axis for the rota-

tion movement, are, in my opinion, the explanation of the greater frequency of the lesions of the internal lateral ligament.

From the clinical standpoint, it is undeniable that the external surface of the limb is more exposed to injury than the internal. Forces acting from outside to inside increase the angle in "valgus" and hence injure the internal ligament.

The cadaver of course lacks the muscular tone which might modify the resistance of the tissues and the form and direction of the trauma, but they have, nevertheless, corroborated the greater frequency of lesions of the internal ligament. In these experiments we frequently obtain partial or total rupture of the upper end of the ligament from its insertion; sometimes a bony fragment of the condyle is plucked off. Very seldom do we observe rupture of the lower end of the ligament.

Fessler, working on cadavers, verified the frequency of the ruptures at the ends. He thinks this is due to the fact that the ligaments are thicker and therefore stronger in the middle. In these experimental ruptures, we also observed tearing of the body of the lateral ligaments and the capsule and sometimes rupture of the crucial ligaments.

Pathology. Very different are the lesions that the lateral ligaments may present. They may be partially or completely broken, and this rupture may occur in the ends or in the body itself. Auvray reports a case in which the internal lateral ligament was broken through near the upper end. Duval has described a rupture of the internal ligament in the midportion, in which the fibers were not all broken at the same point, some being torn in the upper third, others in the middle, and the rest in the lower third; none was torn from its insertion.

Guichard mentions a case of a rupture in the lower end. Harbin has observed two cases of transverse tearing in the body of the internal lateral ligament. One of Penin's patients showed a small piece of the head of the fibula plucked off, with external

popliteal sciatic palsy. Tixier and Rougemont have also observed a similar case. In our five cases, there were three ruptures in the upper end and two in the upper middle part.

We can state that (1) incomplete rupture is rare; (2) the ligament most frequently injured is the internal; and (3) the upper end is most often affected.

Among the complications which may appear are: (1) the lesions of the capsule, the semilunar cartilages and the crucial ligaments; and (2) partial fractures at the ends of the ligaments which may produce the paracondylar ossifications known as Stieda-Pellegrini syndrome, the partial fracture of the head of the fibula and paralysis, when the external ligament is affected.

Symptoms and Diagnosis. Symptoms of rupture of the lateral ligament vary according to the seriousness of the injury. Generally, slight injuries, caused by minor trauma, produce "hemarthrosis," tumefaction, limitation of motion of the knee joint, ecchymosis, abnormal lateral mobility of a few degrees, and periarticular pain. Too much importance need not be attached to the pain in the ligaments since a few weeks of rest, generally advised in these cases, causes the hemarthrosis to disappear. The patient is then allowed to walk. In many cases, the trouble disappears, and the patient is cured. Excessive anteroposterior mobility may remain but often is not very pronounced and does not produce articular instability. Neither the physician nor the patient is likely to bother about the remaining lateral mobility and the troublesome walking that uneven ground produces.

It is only the persistence of these symptoms that sometimes leads the patient to the specialist. Then physical examination reveals a lateral articular mobility which indicates a lesion of the inner or outer lateral ligament.

In these "slight cases" even more than in those which are more serious, rupture of the external lateral ligament produces a lesser clinical picture than rupture of the

internal one. The physiologic "genu valgum" makes weight-bearing more comfortable when the torn ligament is the external.

Aside from such serious injuries as occur in those run over by heavy vehicles traveling at high speed, buried by a block of earth or by a building, etc., there are "medium" lesions where at physical examination we find a wide lateral mobility of 2 or 3 cm. or even more, from one articular surface to the other, indicating a serious rupture of the lateral ligament and the capsule. This lateral mobility allows the leg to be placed in very clear "varus" or "valgus" position, according to the injured ligament.

Another symptom which is observed in these patients is the bloody infiltration which accompanies the tearing of the soft tissues; it is a more or less serious hematoma in one of the lateral surfaces, very different in aspect from that shown by an intra-articular collection. The soft tissues are thickened, the skin is infiltrated and very hard to slide over the deep planes. The finger, palpating lightly, finds a "slot" at the most painful point, where the tearing is more pronounced. This slot becomes greater in lateral movements of the leg.

In these patients, after the early stage is passed, we find the typical picture of rupture of the lateral ligament, with the following symptoms:

Lateral Mobility. To test for this, place the patient on the table with the knee extended. With one hand, hold the lower part of the thigh, and with the other, grip the lower part of the leg. Meanwhile, try to immobilize the thigh and move the leg outward or inward laterally, according to the injured ligament. The rupture may be serious enough to separate both articular surfaces 20 or 30 degrees.

Rotation Movements. With the patient in the same position, using the same technique, with the hand that grips the leg, rotate it outwardly. In rupture of one of the lateral ligaments, this movement is a little greater than in a sound knee. If both ligaments are torn, the rotation allowed is very great.

Recurrent Sprains and Hemarthrosis. Patients who retain a definite lateral mobility, and especially when the internal ligament has been torn, often have slight sprains which are caused by sudden movements without muscular control. Separation of the articular surfaces occurs, producing slight pain and sometimes an increase in the size of the knee by a collection which is generally not very great. These sprains may also result from walking on uneven ground.

There may be a painful point in the ligament itself or in its insertions. The pain is very severe immediately following the initial accident, but becomes weaker as time goes on. It must not be confused with the pain of rupture of the semilunar cartilage, where the painful point is over the articular line. As the pain is often found in the upper end of the internal ligament in "sky" lesions, some authors have called it, "sky painful point."

If the trauma has been slight, the symptoms are not very noticeable. In serious cases, with associated injuries of other elements of the joint, they may be mixed up with the symptoms of these new lesions.

X-ray examination should include frontal and lateral views and curved films with the knee in flexion. Partial fractures of the tibial spines and tibial condyles will thus not be overlooked, differential diagnosis will be simplified. Roentgenograms taken with the knee in the position of utmost lateral separation of the articular surfaces (applying the Kirshmayer technique) show graphically the lateral mobility at its greatest.

Mandl described three clinical forms:

1. Lacerations at the ends of the ligaments, with the following symptoms: Contraction of the quadriceps is difficult and painful; the patient suffers when he leans on his limb or when he tries to flex the knee; it is not possible to obtain lateral mobility, but palpation with the finger

produces a sharp pain in a fixed and localized point of the ligament.

2. Ruptures in the body of the ligament without associated lesions always produce pronounced articular collections. Active and passive movements are very painful, especially the former which is nearly impossible. The principal sign is that it is possible to obtain abduction (when the ligament torn is the internal one) or adduction (if the ruptured ligament is the external).

3. Rupture of ligaments combined with an intra-articular lesion. In these cases, the trauma has been severe. There is no active movement, but there is great swelling with edema, ecchymosis and intra-articular collection; if a dislocation outwards or inwards accompanies the lateral mobility, we may find instability, rupture of the semilunar cartilages or of the tibial condyles, the head of the fibula, etc.

Although this is a very schematic division, it corresponds closely to the clinical pictures to which we have referred as slight, medium and serious. The "slight" cases show ecchymosis, some infiltration of the soft tissues, slight hemarthrosis, limitation in flexion and extension, pain in the torn ligament or over its insertions, and a few millimeters of lateral mobility, never more than 1 cm.

The "medium" cases show bloody infiltration of the soft tissues, large lateral hematoma, extensive hemarthrosis, pain over the torn ligament and its surroundings, great limitation of movements and excessive lateral mobility which reaches 2, 3 or more centimeters.

"The "serious" cases are those that we see after severe accidents, which may have dislocations of the knee and other associated lesions. In these cases there is very pronounced external mobility.

Treatment. The treatment advised by most authorities consists of immobilization and rest of the joint by means of plaster casts, splints or apparatus. The more serious the lesion, the longer is the period of rest. The majority agree that with this type of treatment even serious cases have been cured completely, and if in some cases a lax joint remains, it can regain normal function as soon as the muscular tone regains its strength. Physiotherapy after immobilization is necessary for this.

Böhler advises from six to eight weeks of immobilization in those cases in which the joint can be opened a few millimeters, and from ten to twelve weeks when this opening is greater. More or less, these are the periods endorsed by the majority of the specialists. If there is a large intra-articular collection, it is advisable to aspirate the knee and drain it as often as necessary, following this with the application of a tight bandage. When the collection has disappeared, a plaster cast is applied from the groin to the ankle with the leg extended. Particular attention must be given to the position of the knee, because hyperextension will give too long a ligament and flexion too short a one. If the knee is not immobilized long enough and massage and mobilization are carried out from the beginning, a more or less pronounced lateral mobility may remain.

It is well known that with a more or less prolonged immobilization followed by physiotherapy, we can obtain wonderful results, similar to those observed in rupture of the crucial ligaments. It is also accepted that cases which, in spite of the treatment, retain a lateral mobility which produces articular instability and recurrent sprains, should be treated surgically. This is also necessary where immobilization is insufficient.

The treatment that we use in slight lesions of the lateral ligament is as follows: (1) immobilization with the knee extended for two to eight weeks, or until the capsule and ligamentous lesions are recovered; (2) active and passive movements of the joint, massage of the muscles and exercise in apparatus until strength and function are nearly normal—this takes from one to four weeks; (3) walking, with continuation of physiotherapy for one or two weeks, until full recovery has taken place.

In the medium cases in which the articulation can be opened several centimeters, and in which associated lesions are

FIG. 1.

presumed, we may consider two types of treatment: (1) immobilization from ten to twelve weeks, followed by several weeks of physiotherapy, amounting to four or six months of incapacity, or (2) early surgical treatment. All authors accept late surgical procedures for those patients where prolonged immobilization does not succeed and lateral mobility with instability of the leg remains, but only a few advise early intervention. However, in view of the results obtained in five of our cases, we believe that these patients should be surgically treated at the end of the first week. Exploration of the joint, removal of the semilunar cartilage if it is broken or torn, suture of the capsule and repair of the ruptured lateral ligament should be carried out. If there is fracture of the tibial spine, we reduce and nail it; if we observe a rupture of the crucial ligament, we rebuild the ligament if necessary. We advise this procedure especially for industrial acci-

dents, and for young patients who have special reasons for returning to their jobs as soon as possible.
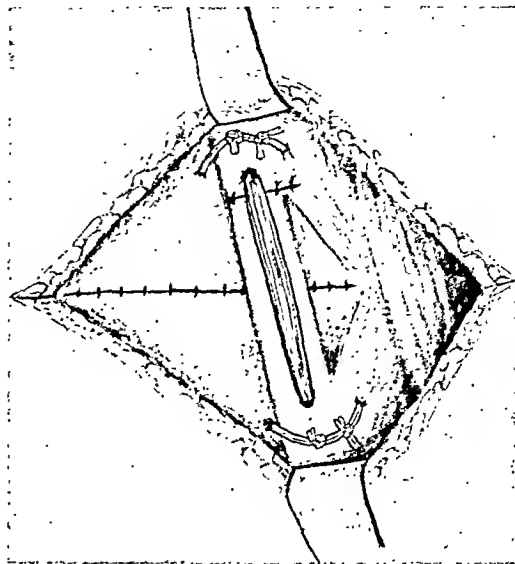
FIG. 2.

In the great majority of cases we obtain good results with conservative measures. However, if the patient will be incapacitated from four to six months before complete recovery or will require surgical procedure later on, there is an undeniable advantage in early intervention. This produces total recovery, allowing treatment of the associated lesions, in a relatively short time.

In the "serious" cases, with associated visible lesions, we advise surgical treatments from the very beginning. This at the same time takes care of the capsule, semilunar cartilages, crucial lesions and also the rupture of the lateral ligaments. Mandl, Oudard and Harbin, among others, also advise early surgical treatment in these serious and medium cases.

What kind of surgical treatment is necessary for the lateral ligament? We advise intervention at the end of the first week or the beginning of the second. At that time the tissues have regained their normal state, hemorrhage has stopped and reparative work has begun. Several authors think that it is only necessary to suture the ruptured lateral ligament. Mandl has had,

with this procedure, two good results. We believe that the best thing to do is to create a new ligament since suture of tissue of poor quality with fibers separated into threads, in the middle of a bloody infiltration, is exposed to failure. The same technique is advisable, when after long conservative treatment, functional difficulty, caused by lateral mobility, is still present.

Folding and simply suturing the capsule and the torn ligament, a good procedure in recent cases, does not succeed in the old ones.

There are several plastic substitutes for the lateral ligaments; Putti uses fascia lata and others use the tendons of the neighboring muscles. The majority of these procedures come from Nicolandoni's method, based upon tendon transplants; the most frequently used are those proposed by Alwyi, Spitzy, Haseller, etc. Mandl applied Heller's method in two cases, using the internal muscles of the popliteal region to substitute for the internal ligament, and a piece of the biceps for the external one. Lagomarsino has published in the *Revista de Ortopedia y Traumatologfa* a very clever method of anatomic reconstruction of the lateral ligaments, using parts of tendons. In two cases in which he used this technique, he succeeded.

Personal Technique for the Reconstruction of the Lateral Ligament. The technique that we use is briefly as follows:

A transverse incision is made parallel to the interarticular line and a little above it. The capsule is cut and the joint opened and explored, with a careful search for lesions of the semilunar cartilages and the crucial ligaments. These are treated if necessary. We suture and fold the capsule with chromic catgut, immediately repair the torn ligament, and make a new one. This new ligament is made with four or six threads of thick twisted silk, sterilized by boiling in cianure oxide. These threads are placed in the same direction and the same length as the ruptured ligament, just over it and attached at its normal insertion points. This fixation is made by passing the sutures in a radiated manner, knotting them tightly to the fibroperiosseous tissues. (Figs. 1 and 2.)

We have used thick silk, according to Lange's method in repairing tendons, and our own method of repair of crucial ligaments. The use of silk simplifies the technique and the fixation with several radiating threads may be very tight.

We have treated five patients in this way. In two cases, the external ligament was so reconstructed, and in three cases the internal one, with excellent functional results, so much so that by the seventieth day, the five patients had returned to their usual work. In two cases of internal ligament repair, there remained 20 to 30 degrees of limitation of flexion which did not trouble the patients and disappeared little by little.

When seen three years after operation, the first three patients showed a knee perfectly adjusted, painless and with normal motion. In one of them the semilunar cartilage had been removed and there remained a slight atrophy of the thigh, of about 0.5 cm. Palpation of the knee reveals a strong, tense, and resistant ribbon, giving the same impression as a tendon.

DISLOCATIONS OF THE KNEE JOINT

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IN this discussion only complete dislocations of the knee joint will be considered. Subluxations are a different problem.

The knee is rarely dislocated on account of the great strength of the ligaments which surround and support it. Complete dislocations of the knee joint are due to severe injuries, usually in the nature of a direct blow. Severe indirect blows do, however, sometimes bring about such type of injury.

Most authorities say that complete dislocations are rare and that they make up only about 1 per cent of all dislocations. Many clinics fail to show a single dislocation of the knee. Ritter[4] states that in 23,000 accident cases admitted to the Reconstruction Hospital in New York, only one dislocation of the knee was noted, and that was incomplete. Ransohoff states that in 1,000 dislocations in the General Hospital at Copenhagen there were only two dislocations of the knee joint.

The author has had occasion to treat seven recent complete dislocations of the knee joint. These occurred in a clinic where over 10,000 fractures and dislocations were observed by the author over a period of eighteen years. In this series there were approximately 300 complete dislocations of the larger joints; seven complete dislocations of the knee joint would constitute a ratio of approximately 2.3 per cent. In the author's clinic, as above outlined, the accidents covered both civilian and industrial accidents. Four of the seven dislocations were industrial and three civilian. Two of the civilian accidents occurred in females.

The bony landmarks of the knee are the patella, the internal and external condyles of the femur, the condyles and the tubercle of the tibia, and the head of the fibula. The soft part landmarks are the quadriceps tendon anteriorly, the hamstring muscles and tendons posteriorly. The bones entering into the formation of the joint are the condyles and the patella surface of the femur above, the condyles and the spinous processes of the tibia below, and the patella anteriorly.

The knee joint is supported and stabilized by important ligaments and indirectly or directly by the muscles and tendons which reinforce the ligaments. There are two main sets of ligaments, that is the external and internal. The external ligaments are the most important, consisting mainly of the external and internal lateral ligaments, the quadriceps and its component muscles and tendons, the patella and the patella tendon with the popliteal ligament, posteriorly. In addition to these the capsular ligament entirely surrounds the joint. Considerable support is obtained by the gastrocnemius and the tendon of the semimembranosus muscle.

The internal sets of ligaments consist chiefly of the anterior and posterior crucials, which serve to stabilize the joint in the anteroposterior plane as well as to a lesser degree in the lateral plane. The anterior crucial aids in preventing the tibia from being dislocated anteriorly. The posterior crucial likewise prevents a posterior dislocation of the tibia on the femur.

The lateral ligaments are the main stabilizers of the knee and an injury to the lateral ligament scarcely occurs without damaging the crucials. All the muscles of the thigh having attachment below the knee aid in supporting this joint. As a matter of fact the author has seen many knees with permanent injury to the lateral
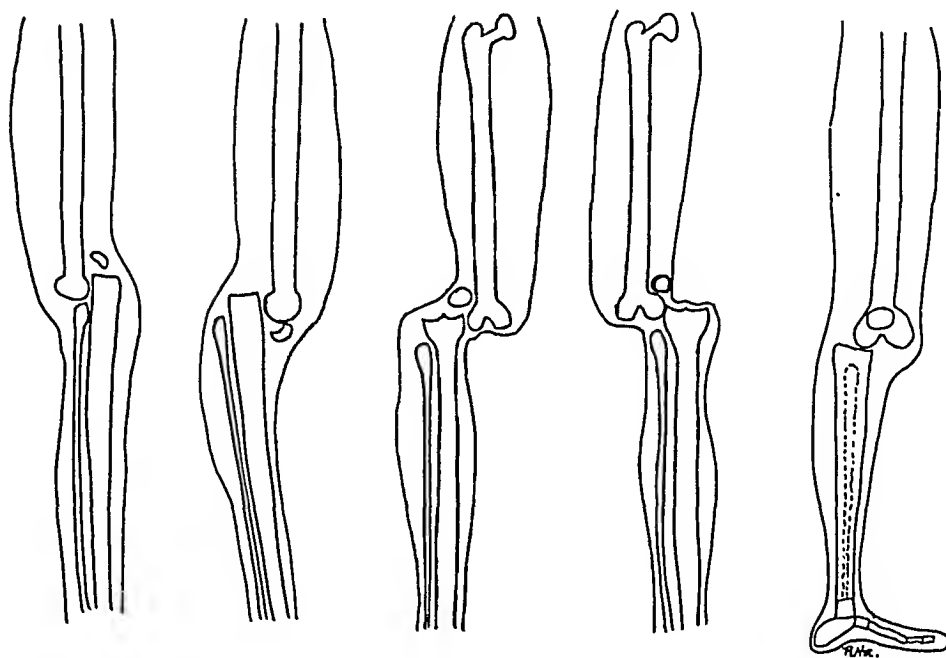
FIG. 1. Types of complete dislocations of the knee joint. Left to right—anterior, posterior, external lateral, medial (internal lateral), and rotary. (From Conwell and Alldredge, in *Surg., Gynec. & Obst.*, 64: 94, 1937.)

A   B   C

FIG. 2. A, radiograph showing anterior dislocation of the knee joint. Treatment, closed reduction with prolonged fixation as described in text. Good functional results as shown in B and C. (From Key and Conwell, Management of Fractures, Dislocations and Sprains, 2nd Ed., Mosby; also Conwell and Alldredge, in *Surg., Gynec. & Obst.*, 64: 94, 1937.)

ligaments which have become functionally perfect due to the supportive measures and development of the quadriceps muscle.

preserved, which emphasizes the importance of prolonged fixation during convalescent treatment.
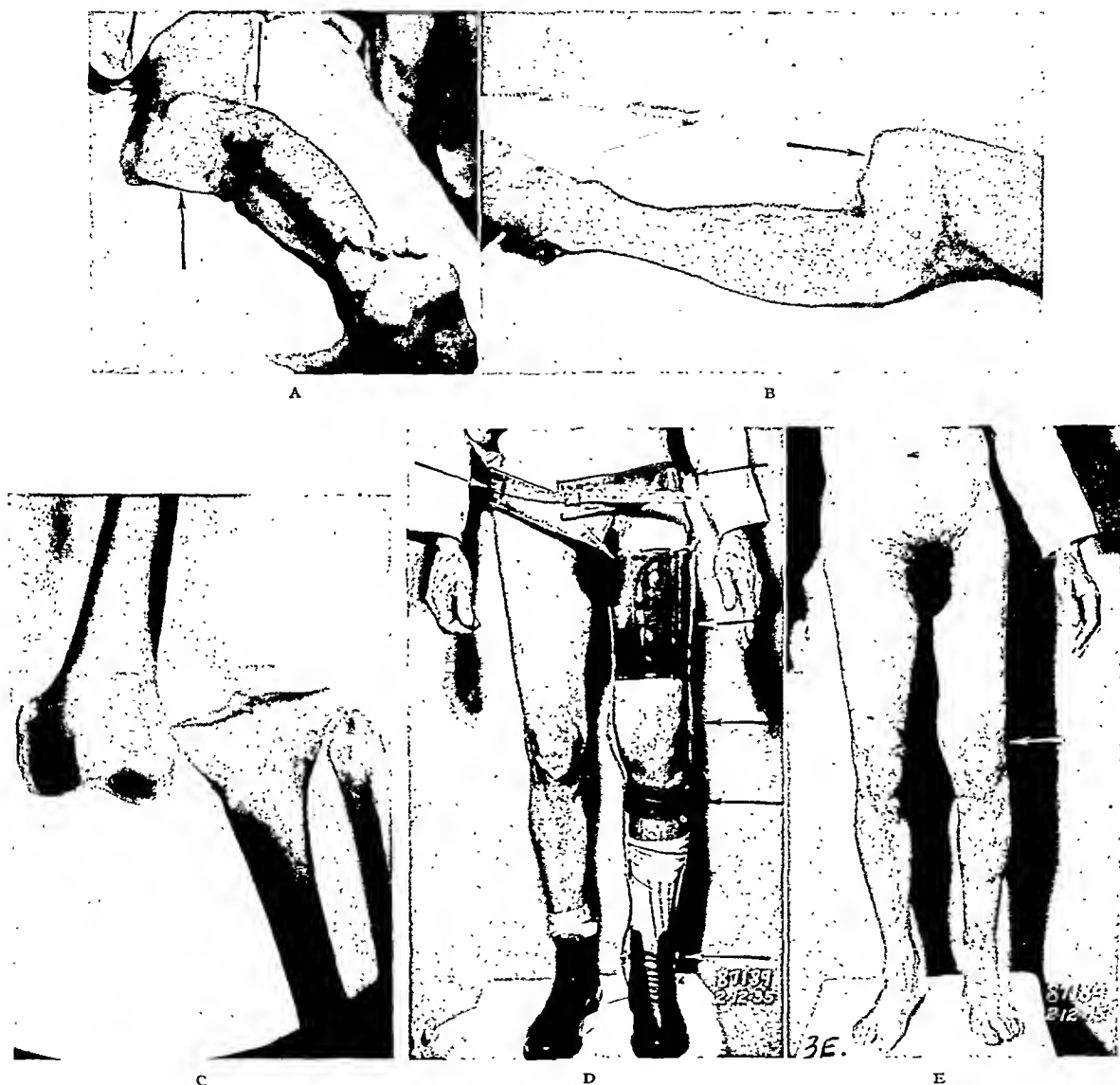
FIG. 3. A and B, rare external lateral dislocation of the knee joint. C, x-ray of same case. D and E, type of fixation used during convalescence after the removal of the cast three months following injury. Patient developed a stable knee with full extension and about 30 degrees of flexion. (From Conwell and Alldredge, in *J. A. M. A.*, 106: 1252, 1936.)

Complete dislocations of the knee are classified according to the relations of the upper end of the tibia to the lower end of the femur, the classification being as follows (Fig. 1): (1) anterior; (2) posterior; (3) lateral (external); (4) medial (internal lateral); and (5) rotary. In any complete dislocation of the knee joint it is readily seen that none of the above ligaments are

The anterior dislocation (Fig. 2A) is the most common type, usually encountered in about 40 per cent of all knee dislocations. It occurs with the knee in full extension, either when direct violence is applied to the anterior lower end of the thigh, driving the femur backward, or when applied to the posterior upper third of the leg near the knee, driving the tibia forward. Posterior

dislocations are second in frequency of occurrence, composing about 30 per cent of knee dislocations. This type occurs while the knee is in flexion and when extreme direct violence is received on the anterior upper third of the leg near the knee or on the posterior lower third surface of the thigh. Indirect violence may in certain instances be a cause. External lateral dislocations (Fig. 3A and B) compose about 20 per cent of all knee dislocations. They are caused by forced adduction of the leg or by direct violence against the inner aspect of the upper third of the leg or against the lower end outer surface of the thigh. Medial or internal lateral dislocations make up about 7 per cent of all complete dislocations of the knee. This dislocation is usually caused by forced abduction of the leg or by direct violence against the external surface of the upper third of the leg or against the lower third internal surface of the thigh. The rotary dislocation is rare. (Fig. 4.) It is usually caused by the leg being caught in a rotating device and rotated about its long axis. There are two types, outward and inward depending on the direction of the toes.

The diagnosis of complete dislocations of the knee joint is usually not difficult, with a history of extreme violence, inability to bear weight, marked pain and deformity of the knee, and a shortening of the extremity. Radiographs should always be made when possible in order to rule out fractures. Other complications should be looked for. Injury to the blood vessels and nerves demands the closest attention. Any mass in the popliteal space with an absence of pulsation of the dorsalis pedis and posterior popliteal arteries indicates a hemotoma from a ruptured vessel and usually demands immediate exploration.

All dislocations of the knee should be properly splinted at the earliest possible moment before any transportation is carried out, and shock should be combated. Closed reduction of the dislocation as early as possible is always necessary under the anesthetic indicated in the individual case. The reduction is usually accomplished

without difficulty and should be perfected by making traction on the leg with pressure over the lower end of the femur and

FIG. 4. Rotary dislocation of the knee joint treated by closed reduction and cast, and knee brace, with good functional results. (From Key and Conwell, Management of Fractures, Dislocations and Sprains, 2nd Ed., Mosby; also Conwell and Alldredge, in *Surg., Gynec. & Obst.,* 64: 94, 1937.)

counter-traction with pressure over the upper end of the tibia in the opposite direction of displacement. Increasing the deformity is not only unnecessary but dangerous, in that it may cause rupture of a vessel or the tear or further injury of a nerve. If, after gentle and careful manipulation, the closed method of reduction is found impossible, open operation should be done immediately. In uncomplicated cases the reduction is not difficult.

Compound dislocations should first have the wound cleansed and debrided, the dislocation reduced and the wound sutured. Gangrene may result in rare instances and amputation above the knee may be necessary.

Following the reduction a plaster cast should be applied extending from the base of the toes to the hip and around the pelvis.

The cast is cut all the way along the anterior surface; circulation of the foot must be closely observed. Prolonged immobilization should be carried out from six to eight weeks, at the end of which time the cast is removed and the patient fitted with some type of brace attached to the shoe, with a pelvic waist band and a lock joint at the knee. (Fig. 3D.) Guarded weight-bearing, crutches, physiotherapy, supervised active motion and hot baths should be continued over a long period of time. The author has seen apparently stable knees after three months fixation become unstable after a month or more without some type of knee support. He has found it unnecessary to do an open operation in these cases in order to repair the ligaments because the ligamentous damage is so extensive there is little chance of operative repair. However, weight-bearing may be allowed after two or three months provided some knee support is used. The thigh muscles require special attention and should be developed to the fullest, because, as previously stated, they aid greatly in stabilizing the knee joint.

The end functional result varies, but in uncomplicated cases if early and proper treatment is carried out, one should in the majority of cases get a painless, stable knee with moderate and sometimes full motion. It must be remembered, however, that a stable knee is far more to be desired than an unstable, painful knee with much motion.

SUMMARY

1. The author reports seven complete dislocations of the knee joint and outlines in detail the different types of dislocations and treatment of same.

2. Complete dislocations of the knee joint should be properly splinted and unnecessary manipulation should be prevented.

3. X-rays should be taken as soon as possible in order to make sure that no fractures are present and also to make further distinction as to exact type of dislocation.

4. Reduction should be done as soon as possible, provided general condition permits. Said reduction being done after administration of the indicated anesthetic for that particular individual.

5. Prolonged immobilization is very necessary in order to obtain a stable knee joint.

6. A stable, painless knee joint is to be preferred to an unstable, painful, mobile knee joint.

7. Amputation may have to be done in certain cases, but this is rare. Circulation should always be closely observed before and after reductions.

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RECURRENT DISLOCATION OF THE PATELLA

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RECURRENT dislocation of the patella may be unilateral or bilateral and in most instances the dislocation is lateral. The affection varies from a mild sense of insecurity or instability of the knee due to slight degrees of lateral slipping, to a severe condition in which the patella is completely dislocated to the lateral aspect of the knee joint. The patella may even be congenitally dislocated laterally. In such cases, it is late in appearing and is usually beneath the iliotibial band which is more or less adherent to, or a part of, the aponeurosis over the patella. As a result of this, it is more or less fixed in the lateral position.

The treatment of congenital dislocation will not be discussed in this paper: it is only mentioned because the author believes that many of the cases of slipping patellae are due to slight congenital contractures between the patella and the iliotibial band. The writer has seen one case of slipping patella, of a mild degree, in which there was a history of mild insecurity of the joint for a period of many years. The x-ray showed the patella to be situated slightly lateral to its normal bed. The pictures also showed a crescentic bipartite patella and on the posterior surface, a small ridge of bone about 1 cm. in height. The patella could be displaced when the abduction test for a tight iliotibial band was done.[13] This derangement of the knee was a true developmental malformation.

Symptoms. The symptoms of slipping or recurrent dislocation of the patella vary in accordance with the disability. In the mild cases there is a sense of insecurity of the joint. In mild injuries there may be synovitis without much apparent reason. These attacks may go on for years before complete dislocation occurs. In those cases where there are complete dislocations from the beginning the disability is acute and very great. There is usually a history of a sudden giving away of the knee and the patient falls down during the attack. Females seem more prone to recurrent dislocations than males. One reason for this is perhaps because women have a greater tendency to knock-knee than men.

Etiology. Recurrent dislocation of the patella may occur in:

1. Knock-knee.
2. Outward rotation of the tibia which begins above the tibial tubercle.
3. High patella, i.e., one situated above the intercondylar notch.
4. Insufficient height of the outer condyle.
5. Congenital malattachment to the iliotibial band and its intermuscular septum.
6. Trauma.
7. Improper closure of median parapatella incisions.

It must be borne in mind that in normal individuals the relation of the femur to the tibia is that of knock-knee, and the size of the angle at the knee depends on the width of the pelvis. If we omit abnormal knock-knee, it will be seen that the normal knock-knee angle, in the presence of the deficiencies given (Nos. 2 to 7), favors a lateral displacement of the patella because the mechanics of the line of pull, from the tibial tubercle upward, shortens the distance from the origin of the quadriceps muscle to its final insertion. The result is a lateral slipping.

Chronic arthritis may develop in these knees as a result of frequent attacks of slipping or dislocation or perhaps from the fact that the patella is never quite in its

normal bed. Arthritis can be produced in animals by keeping the patella out of its normal bed.[2]

Examination. On examination one notes that the quadriceps tendon seems a little slack and that it is possible to displace the patella laterally more than in the normal knee. At times it is possible manually to dislocate the patella when the knee is flexed nearly to a right angle. In those cases where the iliotibial band is involved the abduction test for a tight iliotibial band, if positive, will show slipping or dislocation of the patella. The presence or absence of abnormal knock-knee and external rotation of the tibia must be noted. The relation of the level of the apex of the patella to the knee joint line and the height of the external condyle anteriorly must be noted also. There is the possibility that there has been surgery about the medial aspect of the knee, especially involving the insertion of the vastus internus, or that there has been severe trauma perhaps with fracture of the lateral condyle of the femur or the outer tuberosity of the tibia with malposition.

Treatment. The treatment of slipping patella and recurrent dislocation of the patella resolves itself into efforts to prevent future slipping or dislocation by conservative or surgical measures.

Conservative or non-operative measures will help in many instances, especially when the slipping is infrequent. Of course, no one wants an operation if it can be avoided or postponed. A Thomas lift under the heel and sole will help and a felt or sponge rubber pad, $\frac{3}{8}$ inch thick, 3 inches long and 1 inch wide, placed along the outer margin of the patella and held in place with a 4 inch ace bandage helps to protect the knee and hold the patella. The patient must be told to step down from sidewalk to street level with the sound leg first. If both knees are affected, he must learn to keep from flexing his knees beyond 30 to 45 degrees, and also to avoid sudden twisting of his body on his legs while his feet remain stationary. Finally,

physical exercises to increase the power of the sartorius and vastus internus muscles should be carried out in order to develop these muscles to their highest point of efficiency. This may keep the patella from slipping.

Operative Treatment. Many operations have been devised for this disability. The type of operation must depend on the basic physiologic, anatomic and pathologic conditions present in the individual case.

1. If marked knock-knee alone is responsible for the recurrent dislocation, a linear or cuneiform osteotomy of the tibia, between the epiphyseal line and tibial tubercle, should be done. The cuneiform osteotomy is preferable in adults. The advantage of an osteotomy below the knee over a supracondylar osteotomy is that a leg plaster from the toes to the groin will hold the leg in the proper position, whereas in the case of an osteotomy above the knee a plaster spica must be used.

2. Outward rotation of the tibia is best treated by a linear osteotomy of the tibia above the tibial tubercle. It is not necessary to divide the fibula.

3. For many years in cases of high patella the writer has used the method described by Chandler.[4] In these cases it is my practice to put a Steinmann pin transversely through the patella. The patella tendon and the tibial tubercle are exposed and cleared. A slot is made in the tibia on its medial aspect, as far below the tibial tubercle as the patella is above the joint line, and two drill holes are made through the cortex of the tibia below the lower end of the slot. A mattress suture of heavy silk is passed through the remains of the tibial tubercle and the lower end of the patella tendon. An assistant makes downward traction on the Steinmann pin until the bone and tendon end will fit in the slot. The sutures which have been pulled through the drill holes are tied. The wound is closed; traction is maintained on the Steinmann pin; the leg is encased in plaster, as is the pin, in order to relieve tension until union takes place.

The pin is removed in four weeks and the plaster in six weeks. Some surgeons remove the tubercle in such a fashion as to slide it in a side groove in the tibia so that sutures to hold the tendon in place are not necessary. The disadvantage of this procedure is that the bone may pull away from the tendon.

4. Insufficient height of the external condyle may be corrected after the method of Albee.[1] Albee advocates an osteotomy of the anterior portion of the outer condyle. The condyle is osteotomized parallel to the shaft of the femur. The fragment is raised along the outer border of the bone and a graft is inserted to keep the bone in its new position. The bone must be raised high enough to deepen the depression between the condyles, thus preventing the patella from slipping laterally.[1]

5. In many cases of slipping patellae, there is a strong fibrous attachment, extending from the anterior aspect of the iliotibial band to the aponeurosis at the anterolateral aspect of the patella and a second band, extending from the lateral intermuscular septum to the lateral border of the patella. In such instances, when the knee is flexed, the iliotibial band tightens and as a result, the patella snaps laterally. In these cases it is necessary to free the bands described above down to the joint membrane. The technique for this operation has been described elsehwere.[13] Use is made of a 6 inch flap, ½ inch wide, of the iliotibial band. This flap is dissected free from above downward and passed beneath the aponeurosis of the patella, emerging at the apex of the patella, and is then sutured to the medial border of the tibia through a slot made in the bone opposite the tibial tubercle, thus making an extra patella tendon so that the pull of the quadriceps will be more from the medial side of the tibia and prevent lateral displacement.

6. Traumatic dislocation of the patella may follow fractures of the outer condyle of the femur or the outer tuberosity of the tibia. The treatment is adequate reduction on the fracture.

7. Improper closure of a medial parapatellar incision may result in a slipping patella. The treatment is preventive, i.e., closure of all the structures in separate layers. The incision through the fascia should be placed mesially enough so that there will be enough tissue alongside the patella to ensure suturing in layers. If these wounds are not closed with meticulous care and a slipping patella results, one must then do a plastic repair of the old median incision.

General Discussion. There have been many operative procedures designed to relieve recurrent dislocation of the patella. Goldthwaite[8] many years ago split the patella tendon from the tubercle to the patella and cut off the lower end of one strip of tendon. This tendinous flap was then passed medially beneath the intact tendon and the free end sutured to the medial surface of the tibia. This operation is very satisfactory in those cases where there are no adhesions to the iliotibial band and in cases of knock-knee or torsion of the tibia when the patient refuses an osteotomy.

In 1922, W. R. MacAusland[12] recommended capsulorraphy and transplantation of the border of the patella tendon with the bony insertion of the tendon.

Gallie[7] in 1924 recommended tethering the patella tendon to the medial condyle with a strip of fascia lata.

H. R. Conn[6] in 1925 recommended reduction by traction and anatomic restoration before considering functional mechanism. Conn corrected genu valgus and tibial rotation by the application of successive plasters. This was followed by open reduction of the patella dislocation and the capsular and synovial tissue. He then reefed the medial capsule and restored the lines of torsion of the extensor mechanism.

J. C. Wilson[16] in 1925 advocated running a double strand of silk ligament from the proximal end of the patella tendon to the insertion of the sartorius through a hole in the bone.

Buzby[3] in 1933 advocated a combined Albee and Goldthwaite operation.

Soutter[14] in 1933 used fascia lata, making a tunnel through the patella obliquely from above downward and a similar tunnel over the medial surface of the tibia with a window in the medial border at the lower end of the tunnel. A strip of fascia was passed through these tunnels and sutured at each end to the respective tunnels.

Cole and Williamson[5] in 1934 stated they felt a combination of operations might be necessary and they emphasized straightening the line of pull of the extensor mechanism.

Horwitz[11] published an article in 1937 and discussed the various types of treatment. He favors the simpler extra-articular procedures and recommends the Albee technique in congenital deficiency of the lateral condyle and the intercondylar sulcus.

SUMMARY

1. Recurrent slipping or dislocation of the patella is due to congenital and acquired defects or a combination of both.

2. Chronic slipping of the patella may result, after many years, in a degenerative arthritis of the knee.

3. Conservative treatment in palliative.

4. Operative treatment should be done early to avoid arthritic changes and to prevent accidents to the patient which may occur as the result of falling.

5. The method of procedure followed out should not be limited to one method, otherwise fractures are bound to result. The underlying condition which is responsible for the dislocation must be sought for and corrected in so far as possible.

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ARTHROSCOPY IN THE DIAGNOSIS OF MENISCAL LESIONS OF THE KNEE JOINT*

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INTRODUCTION

ARTHROSCOPY is the endoscopic visualization of a joint. Its technique is simple but interpretation of findings must be based on cadaver experimentation and clinical experience. We have examined about 130 patients with all types of maladies within the knee joint. A good many of our findings, together with the technique used, have been previously published. Reference is made to these publications in the bibliography.

The great interest which injuries of the menisci hold for the medical profession has led us to summarize our experience with arthroscopy in the diagnosis of meniscal lesions.

The arthroscopic examination of the menisci of the knee joint is not always satisfactory. Since the anterior end of either meniscus is covered by the infrapatellar fat pad, it is usually out of the field of vision, and it is, therefore, always uncertain whether this portion is torn, frayed or loose. The posterior end of the meniscus is obscured by its femoral condyle. Thus, while occasionally a tearing or loosening of the posterior third of the meniscus is seen when the meniscus becomes dislocated and displaced forward into a field of vision, it is usually only the middle part, a little more than half the area, which is accessible to the eye.

The appearance of a torn or loosened meniscus is not always the same at arthroscopy as at arthrotomy, which sometimes occasions some confusion regarding interpretation of findings. With increasing experience it has been realized that this is in part due to the hydrostatic pressure of the column of fluid entering the joint. The weight of this column of water flattens out the meniscus. Hence, a freely movable fragment of a torn meniscus, as that part of a bucket handle fracture which is dislocated into the joint space, may be replaced in proper position by the weight of the fluid column. On the other hand, a bucket handle fracture of the meniscus which has dislocated into the intercondyloid space and become fixed there will not be replaced and will be seen properly. The menisci are examined through an endoscope, it must be remembered, and the eye must learn to see and interpret a different spatial relationship.

Atypical fatty formation can easily be mistaken for the meniscus, or a torn part of it, especially when that fat is whiter and denser than normal and properly placed. A freely floating streamer of such fat can be mistaken for a freely movable meniscal fragment. Again, fatty proliferation or synovial inflammation may obscure in part or in whole that part of the meniscus which may be visualized.

Loosening of a meniscus is more easily determined. External pressure demonstrates abnormal meniscal mobility over the tibial surface. The normal meniscus is usually placed firmly on the tibial surface and hence casts little shadow. As it becomes loosened, it may tilt, casting an increasing shadow. These two signs are reliable. An associated tear is always sought for, but

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this may be impossible of visualization, especially if it is in the anterior or posterior parts of the meniscus.
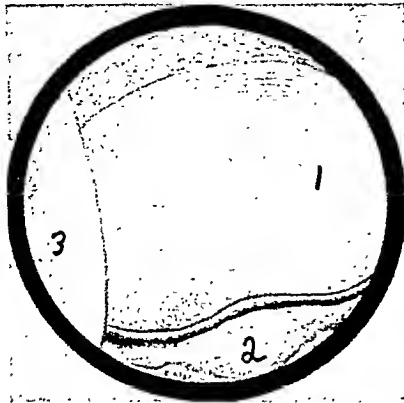
FIG. 1. A giant external meniscus. Note the fact that this meniscus covers most of the external half of the tibial surface. Its pink inner edge is thickened and rolled up. This giant or discoid meniscus was observed in both knee joints of a cadaver. The internal meniscus was normal. 1, giant external meniscus. 2, external tibial condyle. 3, external femoral condyle.

The lines of hyperemia which cross the superior surface of an injured meniscus are helpful in indicating the neighborhood of damage. The vessels are fine capillaries derived from the capsular wall. They are not specific of meniscal tear nor are they constant. They are not caused by the mild trauma of instrumentation.

The usual external puncture allows the examination of only the medial half of the joint; the external half can be examined through a puncture on the inner side of the joint. In some cases, particularly the more complex, it is worthwhile to use both punctures. Otherwise, it is best to localize the pathologic process so that an appropriate puncture may be made. We have erred twice on this; in one case, while the inner half of the joint was well visualized, the pathology lay in the outer half of the joint and a loose external meniscus was removed at operation. This error was unfortunate insofar as vision at arthroscopy greatly exceeded vision at arthrotomy. The operator through the usual small external incision could not

examine the interior of the joint well, because of the great fatty proliferation within the joint. No amount of retracting
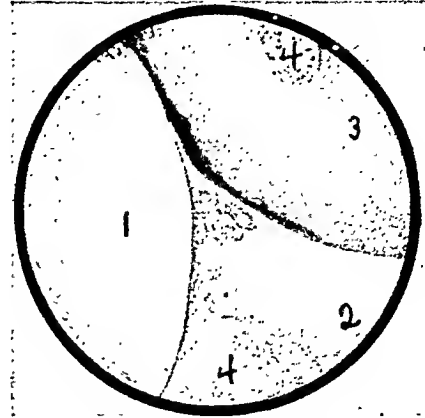
FIG. 2. Case xiv. Internal meniscus is normal. Fat is interposed between the internal femoral condyle and the internal meniscus. 1, internal femoral condyle. 2, internal meniscus. 3, internal tibial condyle. 4, fat.

could properly retract the fat. In another case, vision through the external puncture was exceedingly difficult and no internal puncture was done. At arthrotomy, about four months later, it was found that the pathologic changes were present in the external half of the joint—a loose external meniscus and an osteochondritic focus the size of a large pea on the outer inferior surface of the external femoral condyle being found. The arthroscope had been pushed through the inflammatory tissue in the outer half of the joint; vision of the inner half was poor because the lamp was always in inflamed tissue. Had an internal puncture been done, it would have been possible to see some or all of the disease process. It is true that adherent or inflamed synovia may at one point block vision of another point.

A few points regarding technique: The puncture must be properly made. If it is too high, it is difficult to direct the arthroscope over the condyles into the bottom of the joint. Then the meniscus cannot be visualized. The joint must be aspirated if an effusion is present because oily or hemorrhagic synovial fluid fogs the front lens.

Aspiration should be done several days before arthroscopy and repeated if necessary. The joint cannot be examined when locked since the flexed position of the knee does not permit adequate distention of the joint. The knee should be unlocked, if necessary under general anesthesia, and the arthroscopic examination then carried out. We have examined two patients during the period of locking. In the first case, it was not possible to see the meniscus because of inadequate distention of the joint; in the second case, the knee was unlocked under general anesthesia and the meniscus was then examined.

There are three simple ways by which visualization of a meniscus is increased—increasing flexion of the knee, sometimes to 100 or 90 degrees, forward pressure in the back of the knee, and increasing hydrostatic pressure by elevation of the column of fluid. The latter is effective in pushing away fatty pads which obscure vision of the meniscus.

The value of arthroscopy in a suspected meniscal lesion lies not only in the detection of the actual meniscal lesion, but also in the discovery of other associated lesions. These lesions, which include associated arthritic erosion of the femoral condyle, injury of the anterior crucial ligament and of the fat pads and synovia, etc., may be as significant in the maintenance of an unhealthy knee joint as is the meniscal damage. Conversely, a joint may be saved from operation when no intra-articular injury can be seen.

It is only in exceptional instances of suspected meniscal injury that arthroscopy is indicated. As a rule, the history and physical examination are sufficient to make the diagnosis and warrant arthrotomy. In some patients, however, even the most thorough study leads to nothing but uncertainty. It is in these cases that arthroscopy is of value, particularly when we are dealing with a patient strongly adverse to a major operative procedure. Such a patient will readily consent to an arthroscopic examination. If a lesion of the

meniscus is proved, this is the strongest possible argument to convince the patient that operation is advisable. The findings
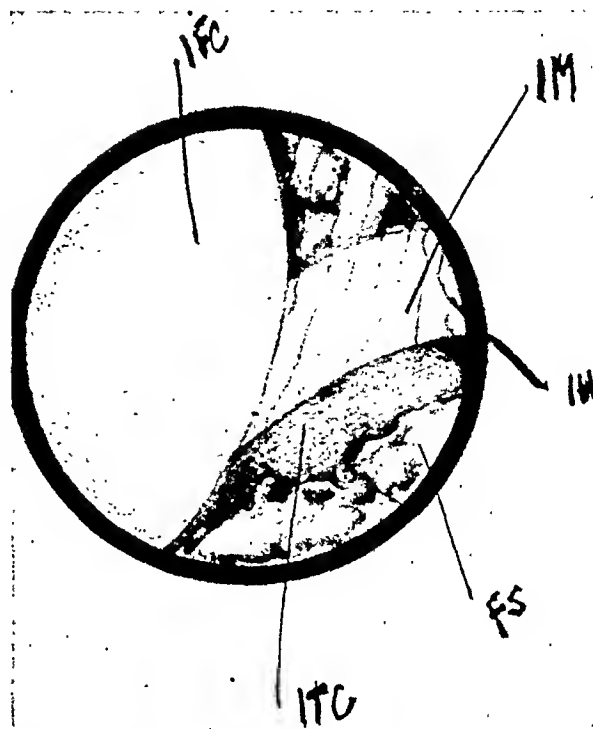
Fig. 3. Note the lines of hyperemia crossing the surface of the meniscus. No demonstrable lesion is seen in the area of meniscus examined. There was loosening of that part of the meniscus beneath the femoral condyle. ifc, internal femoral condyle. itc, internal tibial condyle. fs, fat and synovial membrane. im, internal meniscus.

noted at arthroscopy are sometimes of medicolegal significance, especially in a patient who refuses exploratory operation.

We have examined forty-one knee joints in which a meniscal lesion was suspected. These cases have been subdivided into several groups for the sake of simplicity. There are nineteen cases of definite meniscal injury, all operated on immediately after or sometime after arthroscopy, so that the opportunity was allowed to compare findings. The remaining twenty-two cases were checked at subsequent operations only seven times, so that the opportunity for comparison is limited. These include four types—four cases in which a meniscus had been previously removed, seven cases of suspected meniscal injury, nine cases of knee joints with chronic villous synovitis and moderately marked

fatty hypertrophy with pseudomeniscal symptomatology and, finally, two complex cases.
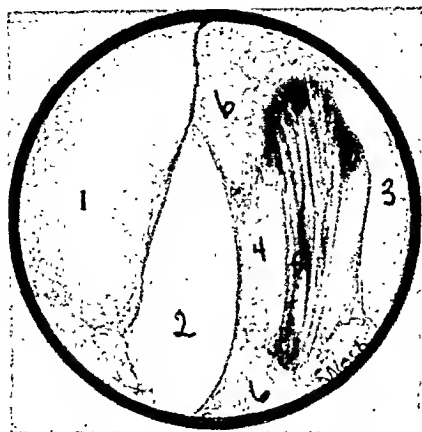
FIG. 4. Case III. The internal meniscus is split longitudinally and the part dislocated into the intercondyloid fossa is fixed there. The anterior crucial ligament is reddened and fibrous. 1, internal femoral condyle. 2, detached part of internal meniscus, dislocated into intercondyloid space. 3, external femoral condyle. 4, intercondyloid space or groove. 5, anterior crucial ligament. 6, fat.

CASES OF DEFINITE MENISCAL INJURY

There were at least eight cases in which the arthroscopic interpretation of the picture of disease so differed from the findings at arthrotomy that they must be reckoned as failures. In the remaining eleven cases part or all of the true picture of disease was properly interpreted. Of these a few showed the meniscal lesion so clearly that there could be no mistaking it, even to an inexperienced eye. Illustrative cases follow:

CASE I. A man of 39 stepped on a radiator to pull a window shade down, and as he did so, heard something tear in his knee. The knee was bandaged for nine weeks and he became symptom-free. He noted occasional swelling of his knee, but there was never any locking. Examination of the knee was negative. The arthroscopic examination on March 9, 1935, three months after his injury, showed a bucket handle fracture of the internal meniscus. The torn part of the meniscus was fixed in the intercondyloid fossa. This was verified by immediate arthrotomy.

CASE II. The next patient injured his left knee four years before admission while playing basketball, and has repeatedly injured his knee

FIG. 5A. Case II. Erosion of the internal femoral condyle. The most posterior part of the internal meniscus is fractured and a fragment is seen beneath the condyle. 1, internal femoral condyle. 2, erosion on internal femoral condyle. 3, internal tibial condyle. 4 and 5, internal meniscus.

since then. There has been only one true attack of locking, although swelling and limitation of motion have often been present. He had also noted a small lump on the inside of his knee which he could push in and out with his finger.

Examination showed no specific tenderness over the line of the internal meniscus. The joint contained fluid and full extension was limited by 5 degrees.

Arthroscopy showed an erosion of the internal femoral condyle. Beneath the condyle was seen a torn fragment of the most posterior part of the internal meniscus, which had interposed itself between the condyle and the tibia. These findings were verified on immediate arthrotomy. It was then determined that the back part of the internal meniscus had split into three parts, the largest fragment being seen as noted, the others being in fields impossible of vision.

The presence of this unsuspected erosion was revealed only through the aid of the arthroscope. For the rest, the history was clear enough of damage to the internal meniscus.

CASE III. A 20 year old youth had landed directly on his feet after exercising on the parallel bars in a gymnasium. He had sharp, sudden, severe pain in his right knee followed by swelling of the knee. Locking was present

on several occasions, and once, after a game of soccer, he was unable to unlock his knee.

A rocntgenogram showed a chip fracture of

Fig. 5b. Case ii. The opened knee joint at time of operation.

the tibial spine. Examination showed flexion limited to 120 degrees both actively and passively. Tenderness was present over the medial joint space. There was no effusion nor ligamentous relaxation.

Arthroseopy showed an intercondyloid displaecment of the internal meniscus. The anterior erucial ligament was reddened. Immediate arthrotomy showed that the posterior half of the internal meniscus had been fractured longitudinally for a distance of an inch and displaced into the intercondyloid fossa. The anterior crucial ligament was reddened and more fibrous than normal.

Case iv. Three years before admission of the 23 year old man, his right knee gave way under him suddenly as he landed on his feet after jumping over a "horse" in a gymnasium. The knee since then had become slightly swollen when strained. Occasionally a clicking was heard in walking or even upon turning in bed. The knee locked in extension while he was ice skating.

Examination was negative except for slight atrophy of the quadriceps muscle. Arthroscopy showed a hypertrophic infrapatellar fat pad and an internal meniscus loose in its midpart. This was proved by external pressure over the meniscus and by the increased shadow it cast on the tibial surface. Immediate arthrotomy proved the arthroscopic findings correct. The internal meniscus and fat pad were removed.

A study of the cases considered failures from our viewpoint, is pertinent. In one, the knee joint was examined in a locked position and the joint could not be adequately distended. In two cases, the wrong half of the joint was examined. In three cases, the tearing of the meniscus (twice internal and once external) was in the posterior part. One of these was an early case so that inexperience might properly
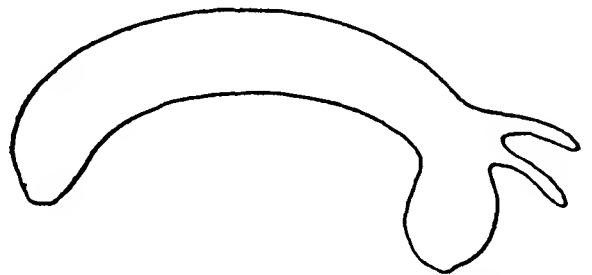
Fig. 5c. Case ii. Diagram of the tear of the posterior part of the internal meniscus. The largest piece was seen beneath the condyle.

be considered one of the causes of failure, besides the fact that most posterior tears are outside of the field of vision. In the second case, the arthroscopic findings agreed with the findings at arthrotomy as regards the general state of the joint but the loosening and tear of the posterior half of the internal meniscus was outside the possibilities of arthroscopic vision. No lines of hyperemia were observed near the

lesion, an observation which proved useful in the detection of a loosening of the posterior part of the meniscus in another
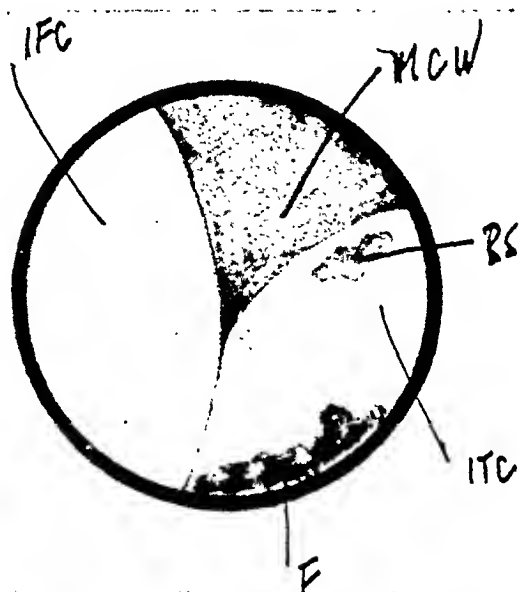
FIG. 6. Inner side of the knee joint in a case in which previous meniscectomy had been done. The internal meniscus has not reformed. IFC, internal femoral condyle. ITC, internal tibial condyle. F, fat. BS, blood serum. MCW, medial capsular wall.

case. In the third case, a pennant of fatty tissue was wrongly interpreted as being the loose fatty detached fragment of a bucket handle fracture. At later arthrotomy, only a loosening of the posterior part of the meniscus was seen. The remaining two cases considered as failures were bucket handle tears of the meniscus. In one, the meniscus was seen to be loose, but the longitudinal tear was not seen. It is possible that the hydrostatic pressure of the column of fluid used to distend the joint altered the picture somewhat. In the last case, a longitudinal furrow was seen in the midpart of the meniscus but the freely floating meniscal fragment was not seen except by one observer who thought he saw the bucket handle fracture seen at operation.

POSTMENISCECTOMY CASES

The four cases in which previous meniscectomy had been done are interesting in the interpretation of persistant symptomatology. Three of them were compensation cases and all of them illustrate the value of arthroscopy in the observation of the general state of the joint.

CASE v. A woman of forty, five years before, had had an arthrotomy for a torn internal semilunar cartilage, the anterior half of the meniscus being removed. Owing to the persistence of pain, she was operated upon again a year later and the posterior half of the internal meniscus was removed. Although she improved, the knee again became painful following an auto accident one and a half years later.

The examination revealed slight swelling of the knee, tenderness over the medial aspect, and restriction of motion (angle of greatest extension, 170 degrees; angle of greatest flexion 120 degrees).

The patient absolutely refused to permit further operation on the knee. The insurance carrier, claiming that the patient's symptoms were largely if not entirely neurotic, insisted that compensation be discontinued. Under the circumstances, both claimant and carrier welcomed arthroscopy as a means of determining the exact status of the joint. The synovial membrane was found covered with numerous fine injected villi, and an erosion of the cartilage on the anterior surface of the intercondyloid fossa was clearly visible. There was no doubt of the diagnosis of a villous arthritis, thus disproving the diagnosis of a compensation neurosis. The court awarded the patient adequate compensation.

CASE vi. A 35 year old man was admitted on November 17, 1932 and a loose, degenerated, internal meniscus removed. Since this operation, he complained of increased pain in the operated knee, aggravated by walking and bending the knee. He used crutches and walked with an exaggerated limp. Pain was said to be present on each side of the joint and the patient kept his knee stiff because of the pain.

Examination showed slight swelling of the joint with an accumulation of a small amount of fluid. The tissues on either side of the patellar ligament were thickened. Extension was possible to only 175 degrees, flexion to 90 degrees.

An internal puncture was used for the examination of the outer half of the joint on April 13, 1933. The only findings were the enlargement of the infrapatellar fat pads and an increase in

the number of synovial villi. These findings were confirmed at immediate operation and only the infrapatellar fat pad removed.

Case vii. A man, aged forty, who in December 1930 had a torn right internal meniscus removed, had since had pain in his knee on walking and had observed occasional swelling. The right knee joint was quite tender on its mesial aspect. Flexion was limited to 130 degrees and motion of the knee was accompanied by a grating sound. He walked with a limp. A diagnosis of arthritis of the right knee was made.

Arthroscopy was carried out on December 2, 1931. A large pennant of synovial tissue was seen on the internal side of the joint attached at one end to the femoral condyle and at the other to the synovial surface of the joint. This did not interfere with joint motion.

At arthrotomy, two weeks later, it was noted that the internal meniscus was absent and the pennant shaped structure seen. It is possible that this represented a regeneration in part of the internal meniscus. Other findings at arthroscopy indicative of an arthritis of the joint agreed with the findings of arthrotomy except that an erosion of the internal tibial condyle had been overlooked.

Case viii. A colored man of thirty-five slipped from the topmost rung of a ladder while descending into a cellar and fell a distance of 11 feet. The history of the injury to his right knee and the clinical course of frequent lockings with swelling of the joint indicated the necessity of removal of the offending internal meniscus. After the operation, he had severe sharp pain on the inner side of the knee, worse in rainy weather. Frequent lockings continued, though they were not so severe as before operation. The patient noted a lump on the inner side of the knee at times, and the knee itself was still somewhat swollen.

Slight limitation in flexion and a slight amount of fluid in the joint were present. The infrapatellar fat pads were tender and enlarged. The internal joint line was tender. On flexion from 165 degrees to 130 degrees a thumping sound was heard which was quite definitely localized to the region of the external meniscus. A similar sound, but of lesser degree, was heard in the normal knee. There was some antero-posterior instability of the knee.

The knee joint was examined through both internal and external punctures on April 4,

1936. The synovial tissues on the inner side were hypertrophic, hyperemic and bled easily. The outer capsular fourth of the internal meniscus was still present. Either this had not been removed, or it is possible that this represented a partial regeneration of the internal meniscus. This structure was quite loose. An erosion was seen on the lower part of the internal femoral condyle. The anterior crucial ligament itself could not be seen, since the intercondyloid fossa was filled with inflammatory tissue. The infrapatellar fat pads were enlarged and fuzzy on their inner surface. Adhesions bound the patella down and the quadriceps bursa, which could only be examined after these adhesions were broken, showed a moderate to marked chronic villous synovitis. The external femoral condyle showed a fine superficial fibrillation. The external meniscus was seen quite well. It was not loose, but its surface was slightly fibrillar and hyperemic. Near the external femoral condyle, a toothlike projection was noted on the inner edge of the meniscus. The synovial tissues on this side of the joint were also hypertrophic and hyperemic.

This man's case had been closed in the State Department of Labor. Two impartial experts appointed by the department examined him on March 13 and 16, 1936. Roentgenograms taken by them showed the formation of a flat mass of bone within the intercondylar fossa of the femur and hypertrophic bony changes. A small osteophyte on the lower border of the patella seemed to correspond to a depression on the external femoral condyle. These roentgenographic changes of the right knee were present in equal degree one month after the injury and three months before his operation. In their opinion the disability was due to hypertrophic osteoarthritis, which antedated the injury. The clocking of the right knee also present to a lesser degree in the left knee, was due, in their opinion, to the gliding of the patellar osteophyte in and out of the condylar concavity.

The value of the arthroscopy done subsequent to the above examination was that it indicated a cause for the patient's disability beyond this evident arthritis. This was the demonstration of a structure in the region of the internal meniscus which seemed to be a regenerating but loose meniscal-like structure. The referee, however, decided against immediate operation, and intensive physiotherapy was advised.

All of these cases showed some pathologic changes of the knee joint beyond the meniscal syndrome. These were essentially in the direction of synovial hypertrophy and inflammation. Two cases showed meniscal-like structures which in the light of our present knowledge can with reasonable allowance be assumed to be incomplete regeneration of the meniscus by capsular infolding and growth or by growth of an outer fringe of meniscus, incompletely removed at operation.

FATTY KNEES WITH PSEUDOMENISCAL SYNDROME

Eight patients in this group range in age from 35 to 56. Five were women. The clinical picture is not characteristic of the usual meniscal tear, but there is enough symptomatology to cast suspicion on it. These knees contain an excess amount of fatty and chronically inflamed synovial tissue which becomes caught between the joint surface, sometimes with resultant clicking, questionable locking and usually with pain. In only two cases was an arthrotomy done for the relief of symptoms, and in both it is fairly certain that arthrotomy should not have been done. Both showed a questionably slight loosening of the anterior end of the meniscus. The ninth case was a young boy with clicking of his knee which at arthroscopy seemed to be due to the interposition of fat between the internal meniscus and the femoral condyle. Arthrotomy showed only a questionable loosening of the meniscus.

CASE IX. A woman, 35 years old, in November 1934 tripped and struck the anterior part of her left knee. The knee was swollen and painful but she was well in two weeks. In January 1936, the knee suddenly straightened out in extension and she could not bend it for ten minutes. When it finally bent, she felt a click as if it were about to lock, but there was never any true locking.

Examination showed a crepitant knee, somewhat swollen on the inner side. The left knee showed 10 degrees more knock-knee than the right. Motions were free but she walked with a limp.

The pertinent finding at arthroscopy on March 18 was the presence of a grayish, edematous fatty tissue which was placed between the internal meniscus at its midpart and the internal femoral condyle. The internal meniscus was normal. There was a slight excess of fatty tissue within the joint.

At arthrotomy, a questionably loose meniscus was removed, together with several large synovial tabs, but the arthrotomy was needless as was proved by the arthroscopic findings.

CASE X. An 18 year old boy injured his left knee five years before when he fell three stories. Since then, he had experienced intermittent periods of clicking in the left knee. At no time had there been any true locking nor any swelling of the knee beyond that at the time of the original accident. Pain was sometimes present, and was more intense in rainy weather.

Examination of the knee was negative except for an occasional clicking sound on the inner side of the knee.

Visualization of the joint on October 4, 1933 was excellent. Several rugous fatty structures were seen between the internal meniscus and the internal femoral condyle. Arthrotomy a week later showed a questionably loose internal meniscus and this was removed. It is debatable whether operation was necessary.

CASE XI. A 41 year old man was admitted to the hospital with a diagnosis of internal derangement of the knee. Arthroscopy of the knee joint on November 21, 1935 showed a moderate chronic villous synovitis. The internal meniscus was normal except for slight fraying of the inner edge. The fat pads were hypertrophic. No operation was recommended.

CASE XII. This man, 38 years old, fractured his left patella four years before. He was well till six months before admission, when he jammed his left foot firmly between two steps, his body twisting to the left. The knee gave way under him. It was swollen and painful and locked apparently in flexion, so that it was some time before he could extend it. The knee remained painful after the accident so that he could not support his weight firmly on it. He walked stiff-kneed because flexion was painful. No further locking occurred, but a clicking could be heard within the knee on extension. The pain on flexion of the knee was localized to either side of the inferior pole of the patella.

There was a small amount of fluid within the knee. The angle of greatest extension was 170 degrees, the angle of greatest flexion 110 degrees. The synovial membrane was thickened.

Arthroscopy on May 27, 1936 showed a marked villous synovitis of the knee joint mostly on the bottom and medial side of the knee joint. The joint cartilage was normal. The internal meniscus, which was well seen, was normal. No operative procedure was recommended.

PATHOLOGIC FRACTURE OF THE MENISCI

Pathologic fracture of the menisci of the knee joint is uncommon and can only occur in the later decades of life. It is based on the progressive degeneration of the menisci with increasing age.

CASE XIII. A colored man of 57 noted gradual swelling of the right knee ten months before admission with increasing difficulty in flexion. He walked stiff-legged to avoid pain. He had a feeling of something snapping within the knee on flexion or extension, but there was no true locking. All symptoms were referred to the inner side of the joint.

On examination, a click was felt on the inner side of the knee joint, usually at about 160 degrees of extension. A slight limitation in flexion was present. Slight periarticular thickening was felt. The fat pads were enlarged, and tenderness was present on the internal side of the joint. Roentgenograms of the joint showed hypertrophic osteoarthritic changes.

Arthroscopy on May 11, 1932 showed a chronic villous synovitis. The joint cartilage was fibrillar. The posterior part of the internal meniscus just before it curved beneath the internal femoral condyle was broadened, fibrillar, frayed out and torn transversely. The anterior part of the meniscus seemed thicker than normal and the relatively normal midpart had lost its sheen. These findings were confirmed by immediate arthrotomy. The anterior end of the internal meniscus was loose. The internal meniscus was removed. Its microscopic examination showed considerable degeneration.

CASE XIV. In the other case in this group, a man of 42 with chronic synovitis of the knee joint, chondromalacia of the patella, and tearing and loosening of both menisci, visualization was so poor that no decision by arthroscopy could be made except that of chronic synovitis

of the knee. The arthroscope was caught in adherent and somewhat inflamed synovial membrane so that only indistinct vision was possible. Oily synovial fluid repeatedly fogged the front lens. Had this fluid been aspirated several days before arthroscopy, it is possible that visualization of the joint might have been better.

SUSPECTED CASES

In the last heterogeneous group of seven cases no operations were done so that the arthroscopic findings were not checked by arthrotomy. In one case of a boy with a traumatic synovitis of the knee, it was impossible to see the internal meniscus because of too high a puncture. This early case is reckoned a failure because of inexperience in technique. In the case of a young man with a questionable meniscal injury the short arthroscope was used, the long arthroscope being out of order. The instrument barely reached to the region of the suspected injury so that adequate examination was not possible. In the other cases definite opinions were offered.

CASE XV. A girl of 19 had fallen and struck her right knee five months previously. She was able to walk with an immediate slight limp and some pain, and was then symptomless for a month. There was no locking at any time and pain was present chiefly on walking. No swelling had ever been present. More recently, she thought she had seen a small lump on the outer side of the knee.

Examination of the joint was negative, and arthroscopy was advised. The external meniscus was seen quite well and seemed to be entirely normal. There were several large synovial villi on the external side of the joint. Arthrotomy was not advised and a month later the patient had no complaints referable to the knee.

This patient has been very properly spared an arthrotomy.

CASE XVI. Another girl, 22 years old, has spastic paralysis for which adductor tenotomies had been done previously. Following a fall out of bed, she developed pain and limitation of flexion of the knee. There was no locking at any time.

Examination of the knee was negative except for the fact that she could not flex her knee beyond 160 degrees, extension being 180 degrees.

Arthroscopy on January 9, 1935 was done under general anesthesia to mobilize the knee. The anterior end of the internal meniscus was traversed by many hyperemic lines. The whole meniscus seemed improperly placed on the tibia as if it had been dislocated medially and rotated posteriorly, but no actual tear was seen in the large area of meniscus examined. The position of the meniscus and the presence of hyperemic lines anteriorly indicated a loosening of the meniscus with a tear of the anterior end.

No arthrotomy was done.

Of the remaining three cases in which operation was not advised, one showed a very questionably loose meniscus. The other patient showed a transverse tear of that part of the internal meniscus just behind the infrapatellar fat pad region. Vision was obscured at times in this case by fresh bleeding into the joint, after the knife blade had cut a small vessel. This bleeding was a unique experience; the slight bleeding ordinarily present is easily controlled by the presence of the trocar as it distends the channel through which it passes into the joint. The patient refused operation, which was indicated in her case both by history of frequent lockings and by the arthroscopic findings. The final case is that of a man of 36 who showed a chronic synovitis of the knee together with chondromalacia of the patella after trauma. The internal meniscus was questionably loose. Operation was not advised.

SUMMARY

It may be said that there are both advantages and disadvantages in the determination of meniscal injury by the arthroscope.

The essential disadvantage is the inability to visualize the entire meniscus. It may yet be possible by means of a suitable retractor built into the instrument to visualize better the anterior part of the meniscus. The posterior part of the meniscus cannot usually be adequately inspected, but may sometimes be.

The important advantage of arthroscopy is its simplicity. Increasing experience gives increasing frequency of correctness of interpretation. The important difference in postoperative course between arthroscopy and arthrotomy can only recommend arthroscopy over exploratory arthrotomy. Arthroscopy should, of course, be limited to those cases in which clinical examination leaves no definite conclusion of internal derangement within the knee. The typical case of meniscal injury will not need this method.

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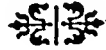
Direct traumatic gangrene is the result of an injury which destroys the vessels within the local zone of trauma, where the parts distal to the injury are deprived of their nutrition and die.

CYSTS OF THE SEMILUNAR CARTILAGE

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CYSTS of the semilunar cartilages are comparatively rare, and a review of the literature recently published[1] showed that the authors all agreed on the symptomatology, signs and treatment of the condition but disagreed as to its etiology. Cysts of the menisci of the knee joint are more common in the male than in the female, and usually involve the lateral meniscus rather than the medial meniscus. Majer has reported one case of bilateral cyst.

Symptoms. The patient is usually a young adult who will tell you about a mass which he had discovered in the region of his knee. The most common complaint is that of constant pain, aching or sharp in character and sometimes described as an actual pinching sensation, radiating up or down the leg but always readily localized in the affected area. A limp or limitation of motion of the knee joint is seldom present but the complaint of easy fatigue of the affected leg is quite often made.

Trauma is not a definite factor in the development of cysts of the semilunar cartilages. However, one does see a hypertrophy of the margin of the semilunar cartilage which is secondary to constant trauma, the symptoms of which very closely simulate those of an actual cyst of the cartilage. Instances of this are seen in hypertrophic arthritis, or following fractures of the condyles of the tibia, or as an end result of permanent changes in the knee joint from acute infection in childhood. All of these conditions produce a sharp projecting margin of bone which causes a pinching of the cartilage and synovia and the development of a hypertrophied mass. This condition should not be confused with a true cyst of the cartilage. Removal of the exostosis and the thickened area of synovia will effect a cure in these cases or will at least relieve the symptoms for a period of years. One must decide at the time of operation whether there has been damage to the cartilage serious enough to warrant its removal.

Physical Examination. The general physical examination of the patient will throw no light on the local condition. Examination of the knee will reveal a mass which varies in size from that of a hazelnut to that of a hen's egg, is tense, rather firm or semifluctant, sometimes rubbery in consistency. The tumor will vary in size in different positions of the knee, enlarging on extension and decreasing on flexion, though the reverse may sometimes obtain. On deep pressure, pain is elicited, and very often it is found that pressure over the tumor when the leg is fully extended will cause the patient more discomfort than when the same pressure is applied with the knee in the flexed position. As a rule, no local heat or redness is present. The tumor mass extends along the attachment of the anterior third of the cartilage and presents over the anterolateral or anteromedial aspect of the head of the tibia. The cyst is generally firmly fixed to the underlying structures but occasionally one is seen which is lying free beneath the subcutaneous tissue. In cases where there is a history of injury there may be some relaxation of the lateral and cruciate ligaments but cysts, themselves, are not responsible for relaxation of the ligaments. Increase in synovial fluid, atrophy of the thigh and calf, and flexion deformities are very uncommon findings on examination.

Diagnosis. The differential diagnosis was so concisely stated in the article published in the *Archives of Surgery* that I am quoting the following paragraph:

"The diagnosis should not be difficult to make. Differentiation from a bursa arising from beneath the medial and lateral liga-

authors are prone to believe that the formation of the cysts starts with trauma and is followed by hemorrhage into the
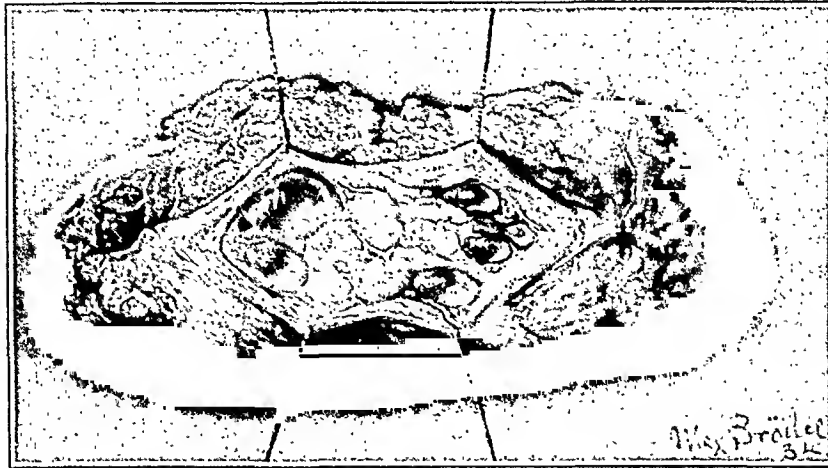
Fig. 1. Gross appearance of the fresh specimen. (From Bennett, in *Arch. Surg.*, July 1936.)

ments and true synovial outpouchings from the joint offer the most common problem. Tumors of the same consistency as the cysts arising from skin, subcutaneous tissue, ligaments, bone, cartilage, lymph and blood vessels and nerve elements might cause some doubt, but tumors of these types are rare in this region. Joint mice or a thickened synovial tag could be responsible for a mass in the proper location, but the history and the associated signs would indicate the diagnosis.

"A distinction should be made between parameniscal and true cysts of the cartilage, but most writers have not done so. Indeed, in many instances this distinction would be hard to make, as the primary cyst arises from the lateral edge of the cartilage and immediately dissects outward through the capsule, thus being parameniscal in the bulk of its growth."

Etiology. The true etiology of the growth of cysts of the semilunar cartilage is unknown. Many authors feel that trauma plays an important rôle, but a review of the cases reported shows that injury was known to have occurred in only about 50 per cent of them. It is also a well established fact that cysts are not associated with tearing of the cartilages. The usual age period is between 20 and 30 years. Most

injured area, mucoid degeneration of the hematoma and the fabrication of a pseudo-mesothelial cyst wall by compression of the surrounding fibrocartilage. These changes are rather acute in character. This theory is accepted by Allison and O'Connor, Nutter and Bloew, Colonna, Folliasson, Jean, Jastram, Heusser, Nové-Josserand, Kroiss, Krapf, Mandl, Orr and Heggie, Pelizaeus, Pyle, Silfverskióld and Sorrel.

Another group tends to believe that the process is less acute, that ordinary wear and tear trauma is an important factor and that the cysts are closely akin to ganglia which we find in other parts of the body. These two theories are not unlike, in that the formation is dependent on a mucoid degeneration of the fibrocartilage. This latter view is accepted by Bristow, Oudard, Seguy and Dalger, Campbell and Mitchell, Phemister, Fisher, Ebner, Edington, Schmidt, Tobler, Nicole and Thorn.

Taylor, in his collection of cases, observes that minor trauma, such as a blow over the attachment of the cartilage, is characteristic in the history. This would account for the cyst occurring more often in the lateral meniscus and for the absence of injury is so many cases. The lateral meniscus is more exposed to blows, and

contusions are less likely to be remembered than injuries which cause gross damage to the cartilage. Taylor has pointed out, too,

King believes that these cysts are the result of the activity of cells secreting a gelatinous fluid.
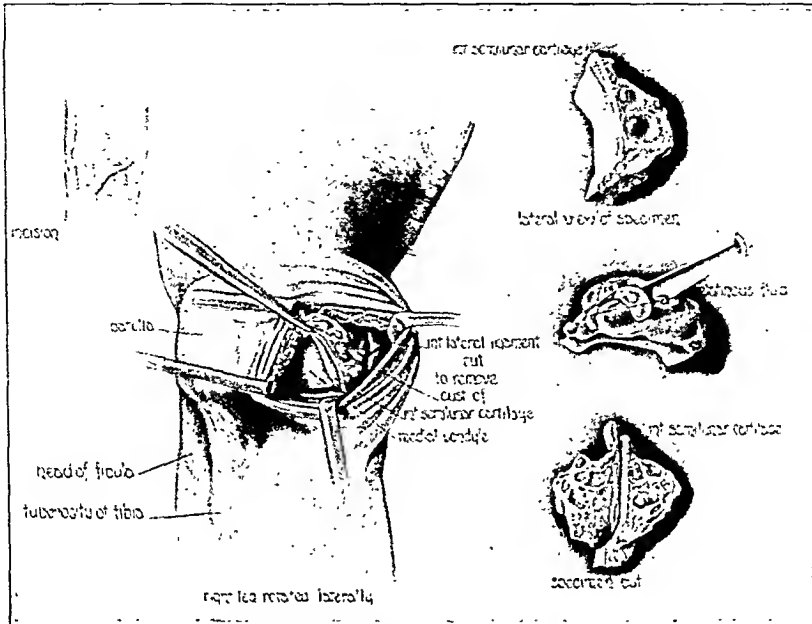
Fig. 2. Drawing showing the location of the cyst, the line of incision, the operative procedure, and the gross appearance of the cyst in toto and in cross section. (From Bennett, in *Arch. Surg.*, July 1936.)

that the cyst always presents in the most exposed portion of the cartilage, hence where there is more likelihood of injury.

Ledderhose's opinion is that obliterative changes in the arterioles of the parameniscal tissues might be a factor in producing degenerative changes in the cartilage. Kleinberg believes that a local change in cell metabolism or, perhaps, injury to blood or lymphatic channels is the initial cause of the degenerative process. Burman and Sutro noted a mucoid degeneration, but no cyst formation, in cartilages removed from persons over 30 years of age.

Ollerenshaw, Zäch-Christen, Kuttner and Venezian believe, because of the nature of the endothelial lining present, that the cysts are congenital in origin. However, the majority of authors feel that this lining is the result of some secondary change, namely, a sphere of compressed fibrous tissue cells.

Majer writes that trauma plus some congenital anomaly is the cause of the formation of the cyst.

Geschickter and Lewis suggest that these cysts are synovial inclusions because they develop at the point of junction of the perichondrium and the synovia, and may be akin to those cysts that arise in the synovial membrane and to ganglia which develop in the tendon sheaths.

Zadek and Jaffe believe the cysts may be the result of synovial implants into the cartilage at the time of trauma.

It is possible that a cyst may arise by any one of these theoretical processes. If a large number of specimens were carefully studied it is probable that more than one type of cyst would be found to exist. Taylor's theory of a blow over the exposed portion of cartilage as a probable cause seems to me most logical.

Treatment. Upon exploration of the knee for a suspected cyst there is no question as to the procedure which should be carried out. Excision of the cartilage in toto is necessary because the simple removal of the cyst itself will not effect a cure. Recurrences have been reported in many in-

stances. The method of removal will depend entirely upon the size of the cyst, but it is usually accomplished by the same

ish or yellowish white, depending on the color of the enclosed gelatinous fluid. The consistency of the fluid is that of egg white.
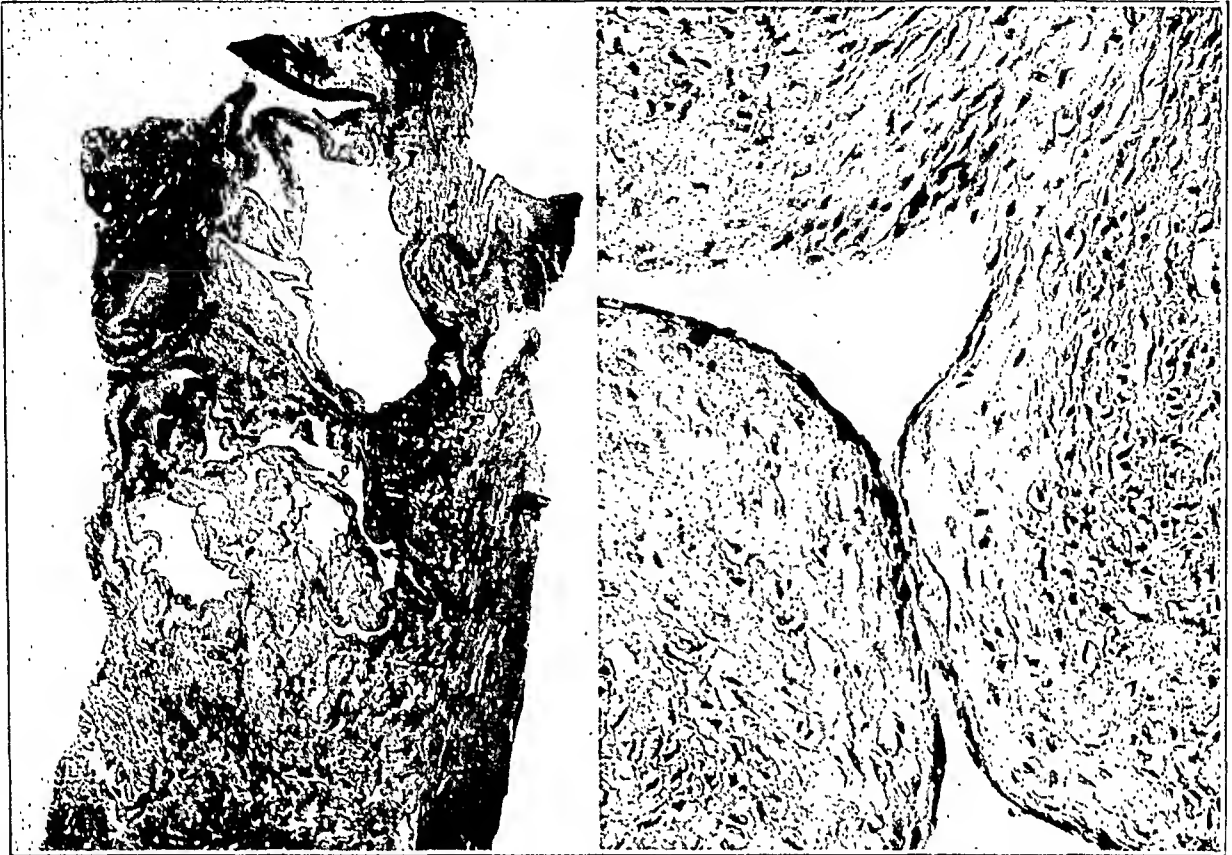
Fig. 3. Low and high power photomicrographs of the specimen. (From Bennett, in *Arch. Surg.*, July 1936.)

technique which is employed for the excision of an external semilunar cartilage. As I stated before, there are cases where chronic irritation caused by the constant pinching of a sharp margin of the external condyle of the tibia or femur will produce a thickening which closely simulates a cyst of the external semilunar cartilage, and while it is possible to do a conservative operation in this type of case it is probably better surgery to remove the cartilage as one does in a definitely proved cyst. The after-care is immobilization in a crinoline or plaster dressing for a period of two weeks followed by active functional use and physiotherapy.

Pathologic Findings. The cysts are from 1 to 5 cm. in diameter and protrude from the cartilage along its capsular border in the middle or anterior third. They have a definite limiting membrane which is gray-

On section the cyst is usually multilocular. The larger portions are located outside the cartilage, appearing in the fibrous tissue of the capsule. Only cysts that are 1 or 2 mm. in diameter are located in the meniscus proper. Rarely does the cyst present within the joint, giving symptoms of synovial irritation. Duval and Moutier and Lecène have reported cases in which the cyst arose near the anterior border of the lateral cartilage and was not connected with the meniscus itself. It apparently arose from the region of the patellar ligament.

Microscopically, the cysts are filled with a structureless hyaline or mucoid material. The lining of the cavity varies from a thin mesothelial-like wall to a rather thick wall, seemingly composed of compressed fibrous tissue cells. Venezian has described villous projections of the wall, but the evidence
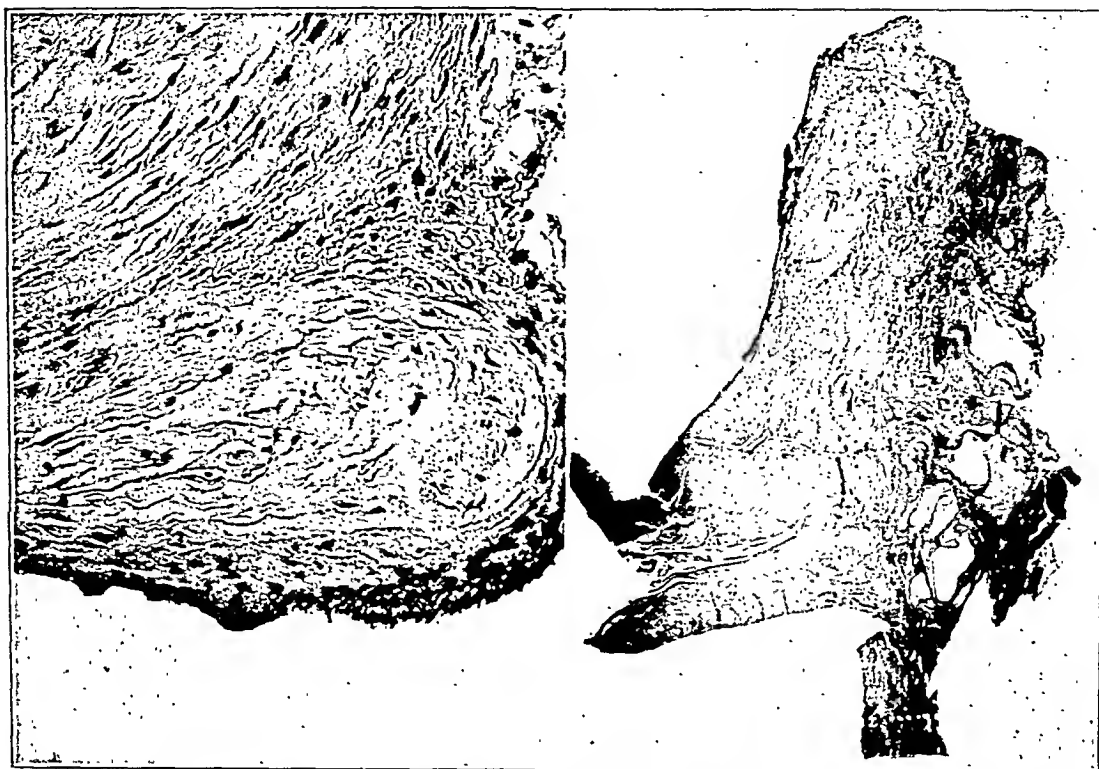
FIG. 4. Low and high power photomicrographs of a cross section of the cyst. (From Bennett, in *Arch. Surg.*, July 1936.)
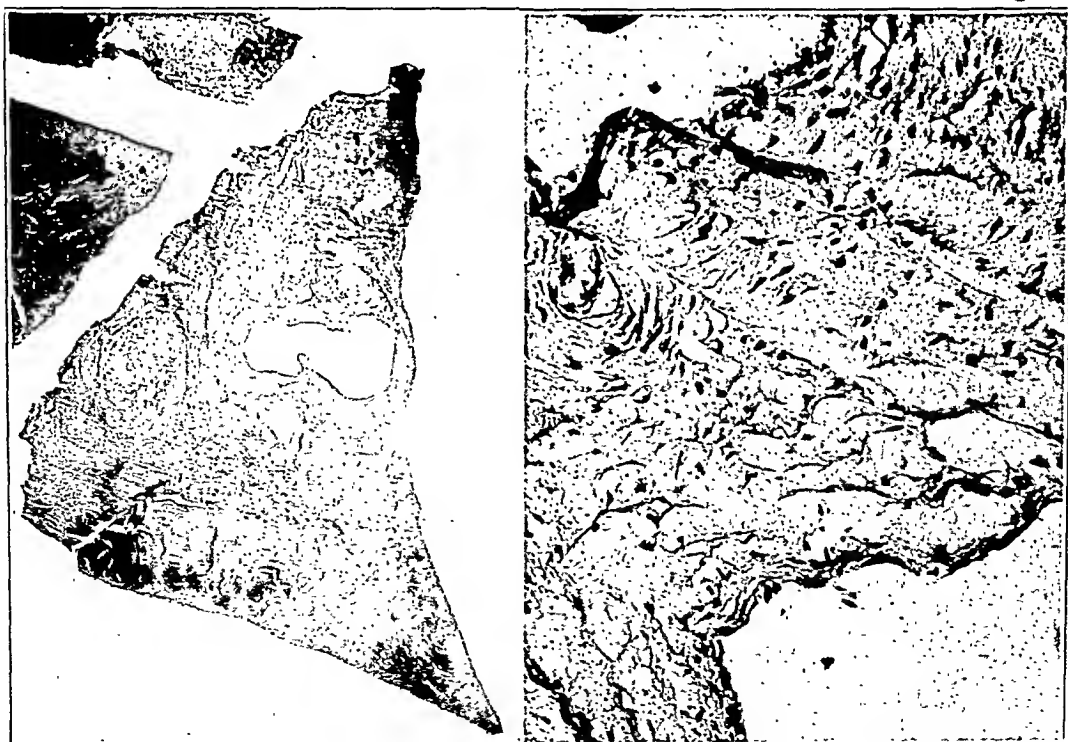
FIG. 5. Low and high power photomicrographs of the specimen. (From Bennett, in *Arch. Surg.*, July 1936.)

does not appear conclusive that these are true synovial-lined cavities.

The ground substance about the cysts is the normal fibrocartilage of the meniscus or the fibrous tissue of the capsule. Occasionally the surrounding structures show a few round cells, as evidence of an irritative process, but no signs of active inflammation have been reported. Meniscitis is a recognized pathologic entity, however. Estor described a case of chronic traumatic meniscitis.

Ledderhose described arteriolar thickening about the cysts, but the majority of specimens have shown no such change. It is more probable that these changes are part of the physiologic aging of the cartilage, as are the mucoid degenerative changes described by Burman and Sutro.

SUMMARY

In this article I have essayed to give an analysis of the location, age group, signs, symptoms and pathology of cysts of the semiluncar cartilages. Extirpation of the cyst with the meniscus will effect a cure. This type of cyst probably arises in a traumatized area in the capsular border of the cartilage, which undergoes mucoid degeneration and cyst formation. The cysts are ganglions of the menisci.

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TEARS of the liver are most often the consequence of blows on the right hypochondrium or the lower part of the right side of the thorax; they may be produced also by contre-coup in the case of falls from a height.

RESTORATION OF MOTION IN FIBROUS ANKYLOSIS OF THE KNEE

WITH THE DESCRIPTION OF A NEW APPARATUS

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THE term fibrous ankylosis of the knee is used to designate the limited passive motion of this joint which results from fibrous adhesions between the gliding surfaces of the joint or periarticular structures. Limited passive motion which results from bony abnormality or the limited active motion which results from paralysis cannot be included in this classification.

The knee joint is particularly susceptible to fibrous ankylosis because of its complex mechanics and structure. The axis upon which motion of the knee joint takes place is not fixed but shifts forward during extension and backward during flexion, a gliding movement being superimposed upon the rolling (hinge) movement. During flexion the patella, in the adult, moves downward a distance of about 3 inches. To permit this wide excursion of motion it is necessary that the elements of the joint and the muscles which control it be free to glide upon each other and upon the bones. The knee joint is therefore surrounded by the largest and most extensive synovial membrane in the body. Adhesions in any part of the synovial cavity will limit motion of the joint.

The selection of the proper treatment to be used in restoring motion to the knee depends upon the accurate preoperative estimation of the pathologic changes present. A careful history and physical examination will usually furnish reasonably accurate data as to the difficulties to be overcome in mobilization of the joint. Adhesions limiting motion may be: (1) intra-articular; (2) periarticular; (3) in the muscles controlling the joint; and (4) in the skin and subcutaneous tissue.

Before any effort is made to restore motion to the knee a careful search must be made for evidence of active inflammation. Mobilization is not attempted if there is an elevation of the local temperature, cellulitis, or open sinuses on the extremity. X-ray evidence of abscesses in the bones which articulate at the knee also prevents mobilization.

TREATMENT

Massage, Active and Passive Manipulation and Use of the Screw Control Knee Brace. All patients are given a few weeks of preliminary massage and manipulation before any operative work is done. This treatment consists of a half hour of manual massage each day along with manipulation of the knee by the physiotherapist. During this period the patient is encouraged to give the knee all the active exercise the deformity will allow. This treatment is given to:

1. Cause the exacerbation of latent inflammation.

2. Strengthen the osteoporotic bone.

3. Determine the strength of the adhesions.

The trauma of massage and active and passive manipulation of the joint will usually cause a flare-up of latent infection. This trauma, being relatively mild, does not result in a serious exacerbation of the inflammatory process which usually subsides following a short period of rest. There is a difference of opinion as to how soon after the healing of an inflammation the area can be safely subjected to the trauma of surgery. Albee[1] recommends that operation be done a few weeks after complete healing because at this time the immunity

of the patient is higher than it will be subsequently.

The bones of the knee joint are usually

FIG. 1. Author's screw control knee brace showing detail of screw mechanism. Three holes are provided on the side bar of the brace for the attachment of the levers. If the knee is very resistant to mobilization the levers are attached at the holes most distant from the fulcrum. If rapid mobilization of the knee is possible the levers are attached at the holes nearest the fulcrum. The brace is usually attached to a high shoe in order to provide a firm, comfortable anchorage for the distal end.

osteoporotic in patients with fibrous ankylosis. In some cases this is due to disuse. In others, in which the limited motion follows rheumatoid arthritis, the weakening of the bone is due to absorption of some of the trabeculae beneath the articular cartilage by granulation tissue. The articular surfaces of the femur and tibia act as the fulcrum during forceful manipulation under anesthesia. Crushing fracture of the condyles may result if the bone is osteoporotic. Massage stimulates the local blood supply and aids in the recalcification of the weakened areas. The stress and strain of active and passive manipulation also stimulates bone deposition according to Wolff's law.

If this preliminary treatment results in a gradual increase in the range of motion, it is continued. To aid in the mobilization of the joint, the screw control knee brace is applied. Since this brace was designed by the author several years ago, it has proved of great help in the mobilization of the knee and elbow. (Fig. 1.) The brace is a modification of the usual double bar knee brace. The side bars extend up to within 2 inches of the tuberosity of the ischium. It is fastened either to the shoe or to a foot plate. There is a free joint at the knee, opposite the condyles of the femur, and a stop joint at the ankle which does not permit plantar flexion beyond 90 degrees. Enough straps and bands are applied to grasp firmly the thigh and calf. One of these bands is placed across the popliteal

space to force the head of the tibia forward. A knee cap is strapped across the lower end of the femur to push it backward. These two opposing forces tend to bring about the normal forward slide of the tibia on the femur as the knee extends. At the knee hinge of the outer bar, a screw is attached in such a way that, by turning the screw in one direction, a force is transmitted through levers to extend the knee. When the screw is turned in the other direction, the knee is flexed.

The brace is worn only at night. The patient applies it an hour or two before going to bed. By slowly turning the screw he stretches the adhesions limiting joint motion. Only a few turns of the screw are made at a time with a few minutes rest between each few turns. This is continued until the limit of motion is secured. The patient is encouraged by the increase in the number of turns of the screw which he is able to tolerate from day to day. When this apparatus is not used, the amount of active stretching the patient will give the knee joint varies with the temperament of the individual. With the brace the patient has a definite duty to perform each day and is able to accomplish a definite increase in the range of motion. The brace is worn overnight at the full limit of the patient's tolerance. It is left off during the day so that he can carry on active exercise.

If the massage, manual manipulation, and the use of the screw control knee brace result in a satisfactory functional range of motion, this treatment is continued. The massage and manipulation are gradually given less frequently. The use of the night brace is continued for a number of weeks after motion of the knee joint is restored to normal, because of the tendency for the recurrence of limited motion. If the massage, manipulation, and active motion do not result in an increase in the range of motion and the mild trauma of this treatment has not flared up the preëxisting inflammatory condition and the x-rays show a recalcification of the osteoporotic

areas, surgical treatment of the deformity can be undertaken.

The Surgical Treatment of the Limitation of Flexion. Three types of operation may be used, the choice of procedure depending upon the preoperative estimation of the pathology present: (1) manipulation under anesthesia; (2) subcutaneous fasciotomy; (3) open fasciotomy with lengthening of the quadriceps tendon.

It is usually difficult to decide which of these three procedures should be used in the treatment of any particular case. For this reason the patient is prepared surgically for open operation before closed manipulation is attempted. By the proper choice of the operative procedure, the hazards of forceful flexing of the knee may be avoided. Undue force may result in a fracture of the shaft of the femur or tibia, crushing fractures of the articular surfaces of these bones, fracture of the patella or avulsion of the patellar ligament or quadriceps tendon. If the preoperative examination shows that the patella is firmly fixed to the femur so that it will not be able to slide through its normal 3 inch excursion, the adhesions fixing the patella must be severed by subcutaneous or open fasciotomy before forceful manipulation is done.

Technique of Manipulation of Knee under Anesthesia. The patient lies on a firm table in prone position. An assistant presses the thigh firmly against the table to protect the femur against undue shearing strain. The surgeon places one hand in the popliteal space to aid in holding the thigh against the table. With the other hand, the leg is grasped just above the ankle, and constant, steady force applied. If fracture of the shaft of the femur is not feared, the manipulation can be done more easily with the patient in supine position. The hip is abducted so that the extremity, from the knee down is over the edge of the table. A sandbag is placed at the edge of the table to protect the structures of the popliteal space against trauma. The assistant presses downward on the thigh, attempting to protect the femur against undue strain.

After a few degrees of flexion have been secured, the surgeon places the sole of the patient's foot against his thigh. When pres-
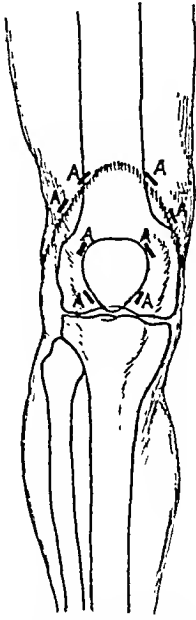
FIG. 2. Diagram showing A, sites of insertion of tenatome for sub-cutaneous severing of periartic-ular adhesions.

sure is applied against the patient's foot, it is forced into dorsiflexion, tightening the calf muscles attached to the lower end of the femur. These muscles become powerful flexors of the knee aiding in the manipulation.

Subcutaneous Fasciotomy. If a reasonable amount of pressure does not result in a satisfactory range of flexion it is necessary surgically to sever the adhesions limiting motion. A tourniquet is not used because it prevents the sliding of the muscles on each other. When tension is applied in an effort to flex the knee, it is possible to palpate tight bands in the periarticular tissue. These are usually located on both sides of the patella and in the anterior thigh at the proximal and lateral borders of the supra-patellar pouch. (Fig. 2). If possible, these adhesions are severed with a tenatome so as to avoid large open incisions. If a large

incision is made, passive motion and massage cannot be carried on during the first two weeks after operation when physiotherapy is most useful. With the patient in supine position, pressure is applied against his foot as described above. A tenatome is introduced through the skin and the most tense adhesions severed. Following the severing of each of these bands of contracted tissue, the knee joint flexes a few degrees. One after the other these bands are sought out and severed. Occasionally an old operative or suppurative scar, located on the anterior thigh, becomes very tense on attempts to flex the knee. These scars can be separated from the bone and the deeper layers of the muscle by subcutaneous incision. When 90 degrees of motion have been obtained, a plaster of Paris cast is applied extending from the groin to the toes, with the knee and ankle at 90 degrees. This cast is molded to produce slight compression over the site of the subcutaneous incisions to prevent postoperative hematoma. The cast is left undisturbed from one to three days, depending upon how extensive the surgery has been. At the end of this time it is bivalved and daily massage and manipulation started. The posterior half of the cast is reapplied at night for a few days. Massage and manipulation are continued daily until the patient has active control of the range of passive motion secured at operation. Weight-bearing is started immediately. The screw control knee brace is worn at night for a number of weeks until all the tendency for the recurrence of the deformity has passed. In some cases the subcutaneous severing of the tight fascial bands in the characteristic locations and the separation of adherent scars do not result in a satisfactory range of passive motion. In these cases it is necessary to do an open lengthening of the quadriceps tendon.

Open Fasciotomy. The usual medial circumpatellar incision is made through the skin extending from the lower pole of the patella up along the medial side of the quadriceps tendon for a distance of 6

inches. The synovia is incised and the joint inspected for any fibrous bands which may be limiting motion. If the knee cannot be flexed after the separation of all these bands, the quadriceps tendon is lengthened by a z-incision. An incision is made halfway through the tendon on its lateral side at a point about ½ inch above the patella. Another incision is made on the medial side of the tendon at a point about 3 inches above the patella. The knee is then flexed, lengthening the tendon. With the knee at 90 degrees, the tendon is sutured with interrupted sutures of No. 1 chromic catgut. The subcutaneous tissues and the skin are closed in layers. A plaster of Paris cast is applied, with the knee and ankle at 90 degrees. The cast is moulded over the site of the incision to prevent postoperative hematoma. It is necessary for this cast to remain on for a period of three weeks to permit early union of the tendon and firm healing of the skin. After the removal of the cast, the treatment carried on is the same as that which follows subcutaneous fasciotomy.

Surgical Treatment of Fixed Flexion Contractures. It is of great importance properly to analyze the pathologic changes present in these cases. If the fixed flexion deformity has been present for some time, the popliteal artery and sciatic nerve and its branches will have become permanently shortened. The distance these structures must bridge is much longer when the knee is in a position of extension than when the knee is flexed. Overstretching of the artery may result in rupture of the intima with thrombosis and gangrene of the extremity. Foot drop frequently results from overstretching of the common peroneal nerve.

The nerve is most susceptible to injury because of its superficial position. Being located farthest from the fulcrum, when the knee is extended the common peroneal nerve must stretch more than any of the other popliteal structures. The danger of injury to these nerves and vessels is greater if the fixed flexion deformity is due to an inflammatory process such as suppurative or rheumatoid arthritis. In these cases the subcutaneous scar frequently extends far enough into the periarticular tissues to incorporate the vessels and nerves, immobilizing them in several places. When they are put on tension all the stretch may occur over a short area between two points of immobilization. The common peroneal nerve is normally immobilized at the place where it winds around the neck of the fibula so it is very susceptible to injury if caught in this inflammatory scar. In many cases of fixed flexion of long duration there is a partial subluxation of the tibia on the femur due to an increase in the backward shift of the tibia which normally occurs during flexion. This is the result of the spasm and shortening of the hamstring muscles. If the posterior thigh muscles and fascia are short enough and firm enough, the subluxation will increase during the forceful extension of the knee. Selection of the proper surgical procedure will diminish the tendency for these complications to occur. The following procedures may be used: (1) manipulation under anesthesia; (2) traction, screw control knee brace or wedged cast; (3) posterior capsulotomy; or (4) osteotomy. In most severe cases of fixed flexion deformity a combination of these procedures is used.

Manipulation under Anesthesia. This procedure can be used only in cases in which the flexion deformity is of short duration and of slight degree. The patient is placed on a firm table in prone position. The surgeon grasps the ankle with one hand and presses downward on the head of the tibia with the other, attempting to force the head of the tibia forward as the knee is extended. An assistant holds the thigh against the table to protect the femur against shearing strain and fracture. It is necessary that the full 180 degrees of extension or even a few degrees of hyperextension be secured if the patient is to have satisfactory function when walking. A plaster cast is applied and the postoperative treatment carried on is the same as that used following manipulation of fixed extension deformities.

Slow Extension of the Knee with the Screw Control Knee Brace, Traction, or Wedged Cast. If the fixed flexion has been present
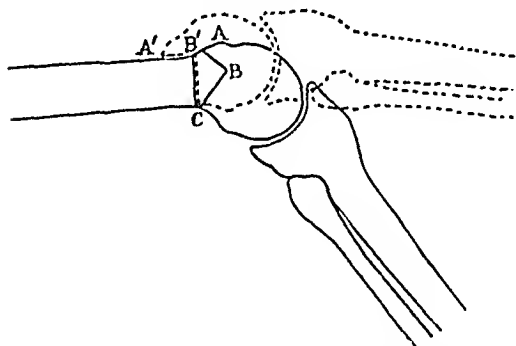
Fig. 3. Diagram of Osgood osteotomy for straightening knee, so as to preserve free motion when it exists. Saw is entered at A, by freeing its end temporarily from bow. Saw incision to B and thence to C. At C saw is removed from bow and left for orientation.

Another saw is entered at B′ and bone incision to C is made. Quadrilateral piece A, B, C, B′ is pushed out laterally. Leg straightened bringing A′ to A and B to B′. (From Albee's Orthopedic and Reconstruction Surgery, Saunders.)

for a number of months, or if there is some subluxation of the tibia present, it is better to stretch the contracted posterior thigh and calf structures very slowly in order to avoid damage to the popliteal vessels and nerves and to avoid further dislocation of the knee.

Of the three methods, it is preferable to use the screw control knee brace for this type of case. The brace is so designed that one of the supporting bands crosses the popliteal space just below the head of the tibia. A knee-cap strap is used to force the lower end of the femur backward. As the screw forces the knee into extension these opposing forces slide the head of the tibia forward on the femur. This change in the relationship of the articulating surfaces is part of the normal mechanism of knee joint extension.

When either skeletal traction with a Kirschner wire through the lower end of the tibia or the screw control knee brace is used, one-half hour of daily manual massage and manipulation is given to supplement the stretching force of the apparatus.

The use of a wedge cast is undesirable because it prohibits this daily physiotherapy.

When the full 180 degrees of extension is secured, the extremity is immobilized in this position by the use of the screw control knee brace. The immobilization is continued until the weakened quadriceps has regained active control of the joint. Walking, daily manual massage, and active and passive exercise are employed. As soon as the quadriceps is strong enough, the knee brace is discarded during the day. Its use is continued at night for a number of weeks because of the tendency for these deformities to recur.

If it is impossible to secure full extension of the knee by these methods or if during the period of treatment any evidence of circulatory or nerve disturbance is discovered, open operation must be done.

Posterior Capsulotomy. In long-standing cases of fixed flexion deformity the principal obstacles to extension are usually the thickened and shortened posterior capsule, the contracted biceps femoris tendon and the iliotibial band. Wilson[2] recommends the open lengthening of these structures. Because of the danger of damage to the shortened popliteal vessels and nerves it is usually safer not to attempt to extend the knee at the time of operation. Wilson states that full extension of the knee can be secured at operation without danger of foot drop if the external popliteal nerve is freed well below the head of the fibula in those cases in which extension of the knee puts this structure on too much tension. In most cases a plaster of Paris cast is applied extending from the groin to the base of the toes with deformity of the knee partially corrected. After a week the slow correction of the remaining deformity is carried on according to the method of the previous section.

Osteotomy. In some cases the flexion contracture has been present for many years. It is evident from a study of the history and physical examination that the popliteal space is filled with scar tissue which holds the shortened vessels and

nerves firmly immobilized. These cases are not suitable for correction of the deformity by any method which puts tension on the structures of the popliteal space.

If there is no motion in the knee joint or if there are a few degrees of painful motion, a wedge osteotomy should be done through the knee joint. The wedges removed from the extensor surface should be large enough to permit ¯1 inch of shortening of the extremity when the knee is fused at 175 degrees. This amount of shortening will not only insure against the overstretching of the popliteal vessels and nerve, but will give the patient a more satisfactory functional result.

If there are a few degrees of painless motion present, a supracondylar osteotomy can be done with the removal of a block of bone 1 inch long from the shaft of the femur. The knee can be immediately brought into full extension if the femur is shortened.

The Osgood[3] technique may also be used. (Fig. 3.) Following osteotomy a plaster of Paris cast is applied extending from the groin to the base of the toes with the knee slight hyperextension. This cast is usually left on for six weeks.

CONCLUSIONS

The type of treatment to be used in the restoration of motion in fibrous ankylosis of the knee depends upon the pathology present. The hazards can be avoided by the use of open surgery in the more severe cases. The screw control knee brace has proved to be of great value in stretching the adhesions limiting motion and in preventing recurrence of the deformity following surgical treatment. Massage and passive exercise must be continued until the muscles have regained active control of the joint.

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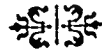
LESIONS OF THE TIBIAL TUBERCLE AND THEIR TREATMENT*

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LESIONS of the tibial tubercle include a rather small field and at first glance one would say no field at all except for a solitary condition, namely epiphysitis. Upon reviewing one's conservative and operative experiences of this region, however, the horizon rapidly widens to include avulsion fractures, periostitis, infrapatellar bursitis, engulfing bone malignancies and surgery of the tibial tubercle directed at the correction of pathology in nearby parts. Such surgery consists in the transplantation of the tubercle for spastic paralysis and recurrent dislocation of the patella and in removal and replacement of the tibial tubercle in complete synovectomy of the knee. Any surgery involving the tibial tubercle, per se, creates pathology at this site and hence must be included.

On several occasions sarcoma involving the proximal tibial metaphysis has been encountered, causing complaints of slight pain in the region of the upper tibia. These on clinical examination occasioned no cause for confusion, since swelling and tenderness were generalized and the tubercle itself asymptomatic. Nearby carcinomatosis has been encountered but again strict localization of tenderness ruled out involvement of the tubercle. While neoplastic destruction of the tubercle area itself may sometimes occur it has not been experienced by us as a primary lesion. Massive changes in the rest of the tibial shaft have overshadowed the tubercle region; x-ray studies prove diagnostic.

Periostitis has occasionally been seen but, unless associated with epiphysitis, has been in adults. In our experience it has been rare, this region apparently being very resistant to trauma. One can almost conclude that if localized symptoms are present, some basic pathology other than periostitis must be responsible.

Infrapatellar bursitis must be mentioned in differential diagnosis. To date we have not encountered a case. Lesions of the infrapatellar fat pad, such as hypertrophy and fibrosis, have occurred in our experience, but the tenderness is localized at a higher level and knee joint symptoms always tend to direct attention to the proper region.

Avulsion fracture has occurred three times in our experience and on two of the occasions has had no association whatever with epiphysitis. Both of these fractures occurred from a combination of direct and indirect violence. Both patients fell on the flexed knee, striking the tuberosity with the quadriceps muscle tense. Diagnosis in each case could not be made clinically since separation of the fragment was moderate and haematoma prevented satisfactory examination. Some loss of extensive power was present but complete loss of or lack of extension was absent. X-ray determined the diagnosis. Conservative therapy was not resorted to, open reduction and reattachment of the fragment being instituted. Both cases went on to satisfactory union and perfect function resulted. One avulsion fracture involved the epiphysis. (Fig. 2.) The method of occurrence was similar to those above. Treatment was by pegging with autogenous bone grafts. The case went on to normal convalescence, reattachment and resulting complete functional rehabilitation.

Cases with epiphysitis of the tibial tubercle far outnumber all other lesions of this region. The exact etiology is unknown. Direct trauma onset with continued in-

direct trauma and circulatory changes probably account for most of the cases. During the past six years it has been our

ferring the pull of the quadriceps muscle through a semifibrous raphe between the fragment and the tibia. One of these cases
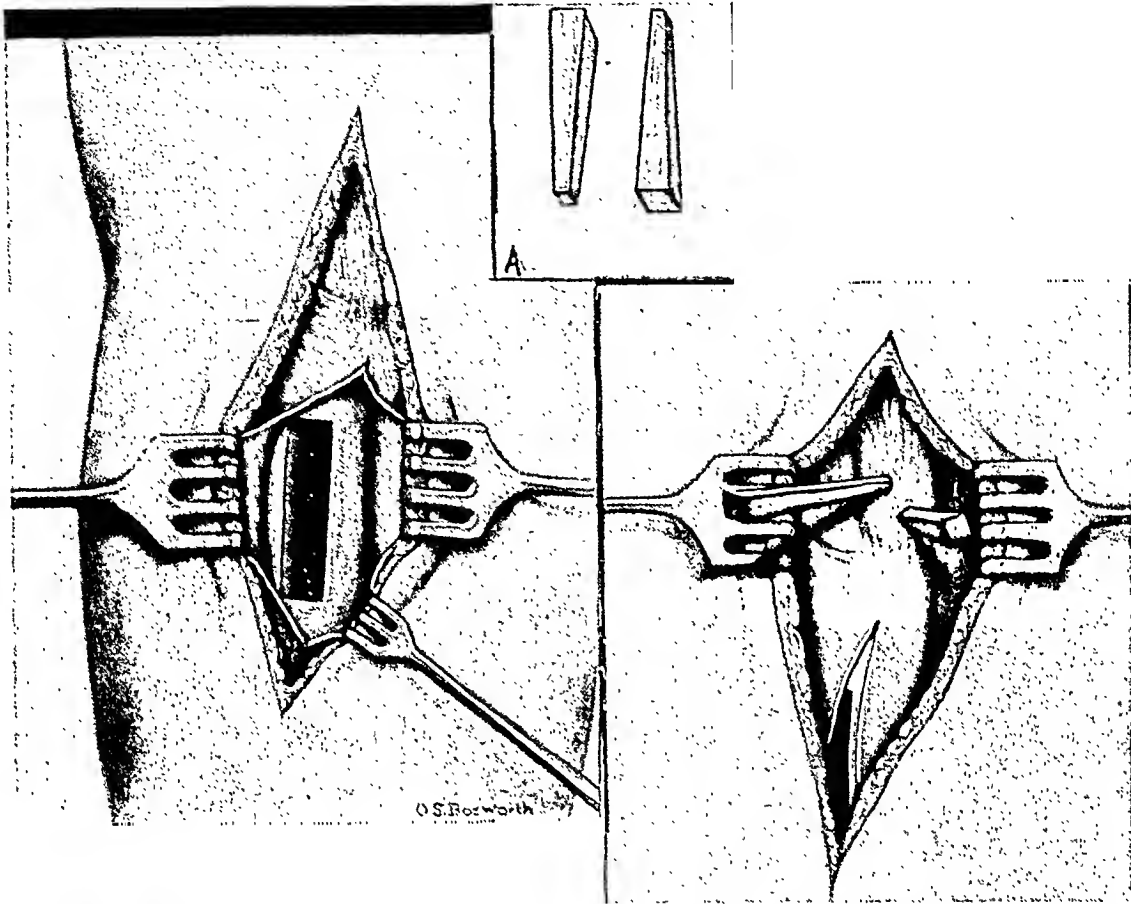
FIG. 1. Drawings show two pegs removed from a single site in the upper tibia through the same incision used to expose the tibial tubercle. The pegs are then placed one through the tubercle and the other just above but in contact with the tubercle. They should be driven through deeply so their bases are submerged beneath overlying soft tissues. Drill holes are made at first but the square pegs being driven into the round holes crease the soft bone. Due to the square and pyramidal shape, they bind the tubercle area down firmly. (From Bosworth, in *J. Bone & Joint Surg.*, 16: 829, 1934.)

practice to peg the tubercle area with autogenous grafts taken from the tibia in such cases as were resistant to conservative therapy. During this period, although many cases of this lesion have been treated, in only sixteen cases has operative interference been undertaken. In four of these both tibial tubercles were involved. In twelve the lesion was either unilateral or conservative therapy was successful on one side. The patients ranged in age between 11 and 20 years. Two of the patients were well beyond the age at which the epiphyseal line should close and the proximal tibial epiphysis had already closed leaving a loose fragment in the ligamentum patella trans-

had been under continuous observation for five years, during which time his symptoms had steadily progressed, and a lesion showing roughening of the tubercle epiphysis at first had gradually formed a separate ossicle in the ligamentum patella. Pain, weakness of the knee in extension, and a limp finally drove this patient to submit to operation which had been advised throughout. All the patients with true epiphysitis underwent preoperative conservative attempts at therapy, half of them for one or more years before pegging was done.

Nine patients gave no history whatever of injury, five had suffered a direct blow on the tubercle and only two patients gave a

history of indirect injury through trauma caused by the pull of the quadriceps tendon. One of these two was the complete avulsion

X-ray appearance of the lesion fell grossly into three classes. The most common appearance was haziness in and about
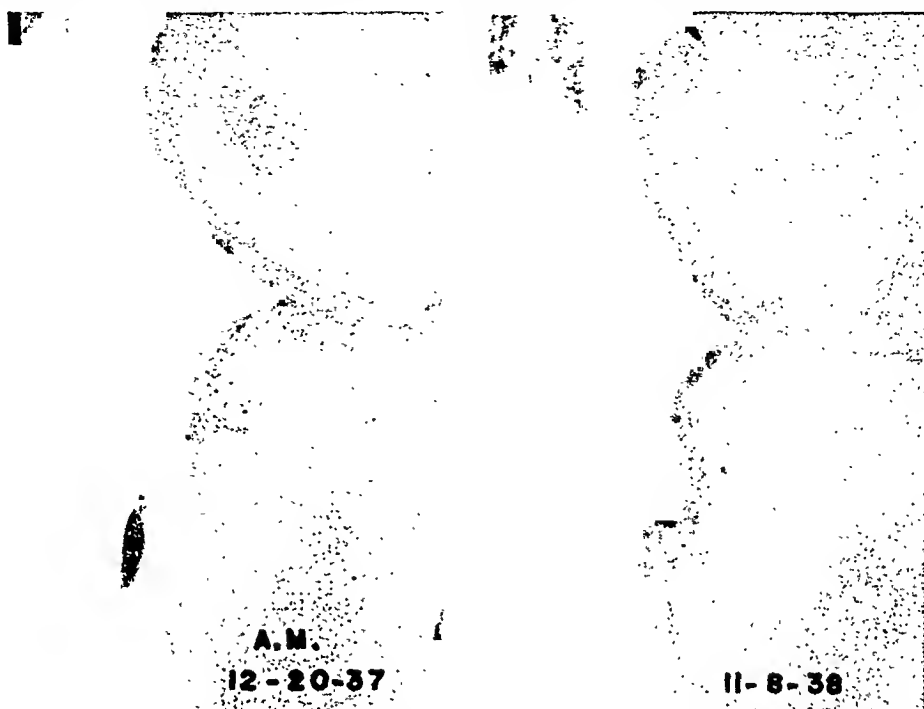
FIG. 2. True traumatic avulsion of tibial tubercle through the epiphyseal plate with reossification of fragment in ten months. Note ossified areas in ligamentum patella. These are asymptomatic in this case.

shown among the illustrations. This is in direct contradiction to the general assumption that indirect trauma or strain is the originating factor. In only one case was there a history of any recent infectious process elsewhere in the body. This supports the statements of most investigators that epiphysitis is not initiated by or related to an infectious process.

Symptomatology varied considerably in intensity but very little in type. All the patients complained of very well localized tenderness about the tibial tubercle alone. Moderate increase in size of the tubercle was present in all except three cases where the examination failed to record the size. Slight weakness in extension was uniformly present. In only three of the cases was a limp recorded and in the case of complete avulsion alone was it of noticeable extent. No associated epiphyseal irritations elsewhere in the body were found in this series. An epiphysitis of the hip was suspected in one case but not found.

the epiphysis with appearance of extraneous calcification just superficial to the tubercle. (Fig. 3.) In three cases the appearance was as though the periosteum overlying the tubercle had been slightly raised. (Fig. 4.) Infrequently, the tubercle appeared bent or sprung forward, though a definite line of fracture across its base could not be determined. (Fig. 5.) All the above were appeareances as seen in the acute stage. Later, under therapy where failure of healing occurred, the appearance was that of a separate bone or bones located in the ligamentum patella just proximal to the tubercle, or within the tubercle area. (Fig. 6.)

The operative procedure has been described in a previous article and will not be repeated. Diagrammatic drawings are appended. (Fig. 1.) In the first two cases a single peg was used but in all later cases two pegs were driven through the epiphysis. Otherwise a separate fragment may be found later in the tendon ununited with

FIG. 3. Typical early epiphysitis pegged after three months of conservative treatment. Loose fragment escaping above upper peg forms separate bone fragment and is included in repegging in D.

FIG. 4. Atypical epiphysitis with lifting of periosteum and result of pegging at three months. Note defect of tibia at point of graft removal is entirely regenerated. This lesion was encountered three times in sixteen cases.

FIG. 5. Unusual epiphyseal lesion with slight bend of the tongue-like tubercle epiphysis at its base which under treatment progressed to further angulation in seven months with irritative changes in the epiphyseal plate beneath it and mild calcification at that site. The epiphysis being pegged, the tubercle is shown completely synostosed to the tibia. A separate ossicle in the ligamentum patella above the pegging has formed, probably from the escape of material at the time of pegging but is asymptomatic at the present time.

FIG. 6. Typical late epiphysitis with formation of a separate ossicle despite conservative treatment. Result of pegging the tibial tubercle with complete assimilation of the loose fragment and closure of the epiphyseal line is shown.

the tubercle. This occurred several times and once necessitated repegging. All wounds healed per primam and no complications of a general nature ensued. Casts were used on the earlier and a few of the later cases. The patients without casts progressed as well as those with them.

Weight-bearing has been begun as early as the sixth day postoperative but we feel that it is advisable to delay for two weeks. Even at this time, of course, no bony union has occurred, but since the extensor apparatus has merely been pierced and not divided no complications due to stress would be expected, nor have any occurred. Loss of acute tenderness and pain accompanying the epiphysitis has been fairly rapid following the pegging but deep tenderness persists until there has been complete reossification and may take several months. Three patients reinjured their knees after complete reossification had taken place. One required repegging, another lacerated the ligamentum patella above the tibial tubercle and in one the symptoms subsided without treatment. Apparently the reattached tubercle is sometimes so strong that the ligamentum patella will give way before avulsion can again occur.

End Results. One patient disappeared and it has been impossible to regain contact with her. The other fifteen patients have been followed to date, with an average time of follow-up of two and one half years. One patient still has deep tenderness.

Fourteen patients were operated upon over a year ago. All of these fourteen have been relieved of their acute symptoms. In one case only does even deep tenderness persist. There is a uniform complaint, present in most of the cases, of final enlargement of the tibial tubercle and resulting pain on kneeling on hard surfaces. Review shows that all pegs in the past have been driven as deep as the soft tissues over the tubercle but not deep enough so their tops were flush with its bony surface (Fig. 3)—hence the final enlargement.

In operating, one peg should be placed proxima to the epiphysis of the tibial tubercle (Fig. 3) and both should be driven well below the level of the soft tissues.

CONCLUSIONS

1. Epiphysitis of the tibial tubercle cannot always be relieved by conservative means, having been observed to exist and progress for from one to five years under such treatment.

2. Autogenous pegging of twenty tubercles on sixteen patients has given prompt and permanent relief of acute symptoms but frequently leaves a slightly enlarged tubercle, painful when kneeling on hard surfaces.

3. Means for preventing the final enlargement and securing more complete ossification of the tubercle area as a result of this study are suggested.

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A NEW OPERATION FOR PRODUCING ANTERIOR OR POSTERIOR BONE BLOCK OF THE ANKLE

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OPERATIVE procedures designed to overcome paralytic foot drop may be classified under two general types:
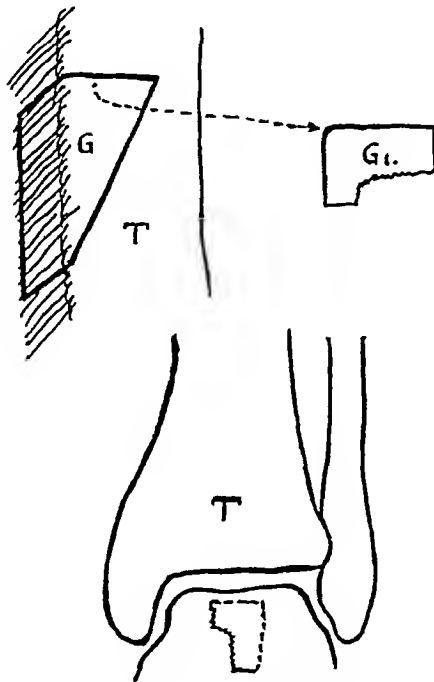
FIG. 1. Diagram showing method of removal of wedge graft from tibia. G indicates wedge graft, G₁, cross section at thick end.

the construction of a check ligament, and the construction of a bone block.

The former operation, tenodesis of the ankle for foot drop, as described by Gallie,[1] consists of the anchorage of the extensor tendons and the tibialis anticus by imbedding them into the anterior surface of the tibia. Observation of the end results of this operation over a number of years has resulted in the conviction that it is not nearly so satisfactory as an operation that utilizes a bone block as a check to joint motion; a stretching of the check ligament practically always occurs.

With a bone block operation, on the other hand, there is a firm stop applied to motion beyond a predetermined arc, and the fact that the results of this type of operation are far more likely to be permanent is attested to by its vastly greater popularity at the present time.

The most popular of the operations for posterior bone block of the ankle are the two operations of Campbell, both of which require the removal of the posterior end of the astragalus. His original procedure replaces the end of the astragalus with a pillar of bone chips obtained from an associated tarsal arthrodesis. Campbell's second operation replaces the posterior end of the astragalus with a similar pillar made by turning up successive shavings from the upper surface of the os calcis. In both cases, since the new bone pillar consists of a large number of chips or shavings of bone, a considerable time must elapse before a firm and solid bone block is produced—a disadvantage that is inherent in chip bone grafts wherever used. Also, the possible frailty of the completed pillar and the failure of union of these chips are contingencies which should be considered.

Other operations that have been suggested have the disadvantage of necessitating a fracture of the astragalus, with a comparatively long period of immobilization, or the operative procedure is technically difficult and time-consuming.

There are two methods of providing a bone block to dorsal flexion of the foot, viz., the method of Putti and that of Albee. Putti's method consists of fracturing the body of the astragalus anteriorly by means

of an osteotome (at about the middle of the body), prying the two portions apart, and inserting into the transverse gap thus

FIG. 2. Diagram showing method of implanting wedge graft. Graft may be placed either anteriorly or posteriorly.

produced, bone grafts obtained from the anterior surface of the tibia. Albee's method consists of displacing downward a sliding graft from the anterior surface of the tibia, the neck of the astragalus impinging against the distal end of this graft when dorsal flexion is attempted.

The following method of providing a bone block at the ankle is equally applicable to paralytic equinus or calcaneus, does not necessitate fracture of the astragalus, possesses the virtue of simplicity, and provides a firm block to motion beyond an accurately predetermined arc.

POSTERIOR BONE BLOCK

An incision is made over the tendo Achilles, which is divided by a z-shaped tenotomy and reflected. After clearing away the loose areolar tissue with a periosteal elevator, the posterior portion of the capsule of the ankle joint is brought into view. A small vertical incision is made into

this, exposing the postero-superior surface of the astragalus, and the postero-inferior border of the tibia. With a $\frac{1}{4}$ inch drill, a

FIG. 3. X-ray of result two months postoperatively.

drill hole is made into the astragalus at the exact spot where it is desired to check plantar flexion. This drill hole is then enlarged laterally and distally by means of a fraisse, so that it has the shape of an inverted L. A second small incision is made over the crest of the tibia, which is exposed by stripping off the muscle from its medial surface.

A wedge of bone is then removed by means of the Albee saw, an oblique and a transverse saw cut being made in the anterior surface, and a longitudinal cut in the lateral surface of the tibia. This provides a very strong wedge graft, consisting of the whole crest of the tibia. This wedge is driven firmly into the astragalus, and seated by blows of a mallet upon the Albee bone drift (similar to an enlarged nail-set). (Figs. 1 and 2.) The tendo Achilles is sutured in the usual manner, with the required amount of lengthening.

ANTERIOR BONE BLOCK

The operation is done precisely as above, except that the first incision is made anterior to the ankle joint, and the extensor tendons are retracted, exposing the anterior portion of the capsule of the ankle joint.

After either operation, a plaster cast is applied for three or four weeks, unless an associated arthrodesis should require longer immobilization.

This operation has now been performed eleven times in the past two years (ten posterior bone blocks and one anterior bone block), in most instances associated with astragaloscaphoid or other arthrodeses. It is too early to report on end results, but to date, no failure to achieve a bone block has occurred, nor has the graft fractured, absorbed, or shown evidence of attrition.

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POSTOPERATIVE subphrenic abscess may follow any acute inflammatory lesion within the peritoneum.

SUBASTRAGALAR ARTHRODESIS*

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SURGICAL fixation of the subastragalar joint alone, or in combination with fusion of adjacent joints, is today generally accepted as a standard procedure to correct deformity, and to stabilize certain feet whose function is disordered through paralysis, disease, or trauma. The sacrifice of the subastragalar and midtarsal joints, where the lateral motions of the foot take place, in no way interferes with the useful function of the foot. By such skeletal fusion, the paralytic with a deformed and unbalanced extremity obtains a foot that is stable for weight-bearing and walking, as well as a foot of more natural appearance. Through arthrodesis of the subastragalar joint, the patient with a foot that is strained and sensitive, as the result of fracture or disease, avoids prolonged disability.

Different problems are presented by the paralytic foot and by the foot that is disabled from injury or disease. Following a crushing fracture, the joints of the foot may be strained and painful from faulty mechanics. The tuberculous foot or the arthritic foot is weak and painful. In these cases the problem is to establish fixation of the joints in order to secure relief from pain and to stabilize the foot. In the paralytic foot, on the other hand, the restoration of balance must be considered in addition to the correction of deformity and the stabilization of the foot. Muscle control being insufficient, better leverage for weight-bearing must be established.

In the first group of cases, subastragalar arthrodesis consists merely of stiffening the joint and displacing the foot slightly backward. In the paralytic foot, in addition to fusing the subastragalar joint operatively, the foot is displaced well backward in order to create a rocker-foot. When fusion takes place with the astragalus lying forward of its usual position on the os calcis, the weight-bearing line is transferred forward, thus establishing better balance and placing the extremity under the best possible control.

The problem of stabilizing the subastragalar joint in the paralytic foot has interested surgeons for many years, and several operative procedures have been devised. Davis, in 1917, was the first to describe this stabilizing operation, and his method formed the basis of procedures that were subsequently devised. The Davis method consisted of arthrodesing the subastragalar joint and the calcaneocuboid joint, and of displacing the foot backward. Among the operative procedures that have become standardized and that are used more or less extensively are those of Hoke, Ryerson, and Dunn.

In 1929, the writer first reported his method of subastragalar arthrodesis, which at that time had been used successfully in seven cases. Continued use of this method has proved it to be a most satisfactory procedure. The technique, in contrast with that of some of the operative procedures in use, is simple. It is a method that ensures solid fixation, provides for the correction of deformity, and allows for displacement of the foot backward to the degree necessary to establish better leverage for weight-bearing.

SUBASTRAGALAR ARTHRODESIS IN THE PARALYTIC FOOT

Indications. In general, subastragalar arthrodesis is indicated in paralytic feet in which the ankle joint is still stable, but in which there is hypermobility in the midtarsal and calcaneoastragalar joints. The

procedure may also be used to stabilize the generally weak foot, in which the ankle-joint is not involved, and in which some with cavus, valgus, or varus deformity associated with calcaneus, and generally weak feet. The cavus deformity is cor-
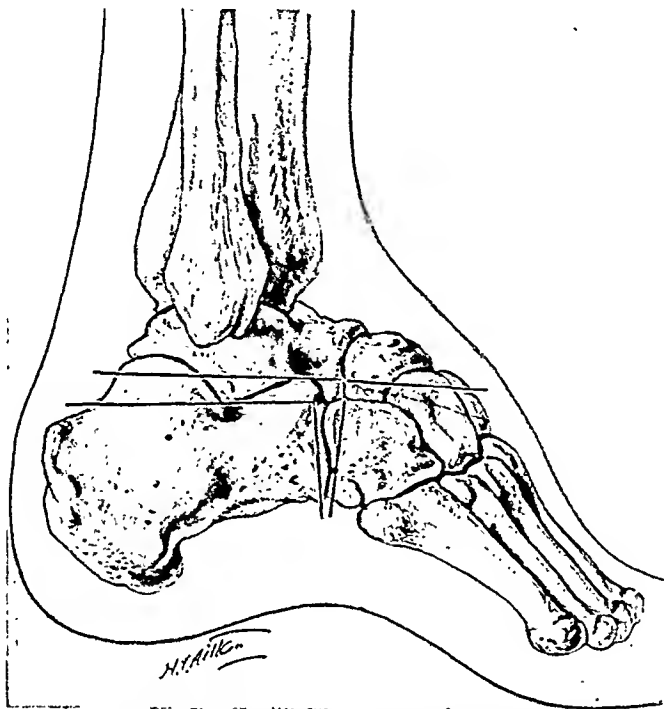
FIG. 1. Diagrammatic drawing showing sections of bone removed from the os calcis, astragalus, and midtarsal and calcaneocuboid regions in arthrodesis of a foot in cavus deformity. Note: The sections of bone removed will vary with the deformity. (From MacAusland in *Ann. Surg.*, 105: 452, 1937.)

power remains in the anterior muscle group.

The indications for the writer's stabilizing procedure are definite. In the first place, it may be considered applicable only when there is sufficient power in the anterior muscle group to prevent drop-foot. Secondly, the posterior muscle group in itself must have sufficient power to prevent calcaneus deformity, or a strong peroneal group must be present whose power, through transplantation, may be substituted for that of the gastrocnemius. The posterior muscle group need have only a moderate amount of power to be efficient in preventing deformity, since less leverage is required once the foot has been placed backward.

The specific paralytic feet, to which the writer's operation is applicable, are those rected by the removal of a wedge from the calcaneocuboid region. Valgus or varus deformity is overcome by excising a section of bone from the lower surface of the astragalus, whose thickness varies on the inner or outer side depending upon the deformity to be corrected. By transplantation of the peroneal muscle group, the power of the gastrocnemius is well substituted. So satisfactory may be this substituted power that a person may even be able to rise on his toes. In the flail foot, lateral instability is overcome by stiffening the subastragalar joint, and better balance of the foot is established by displacing the foot backward.

The best ages for stabilization of the foot are between 12 and 16, although the operation may be carried out in the child of 10 years or in the adult. Arthrodesis before the age of 10 is inadvisable, as the bones are
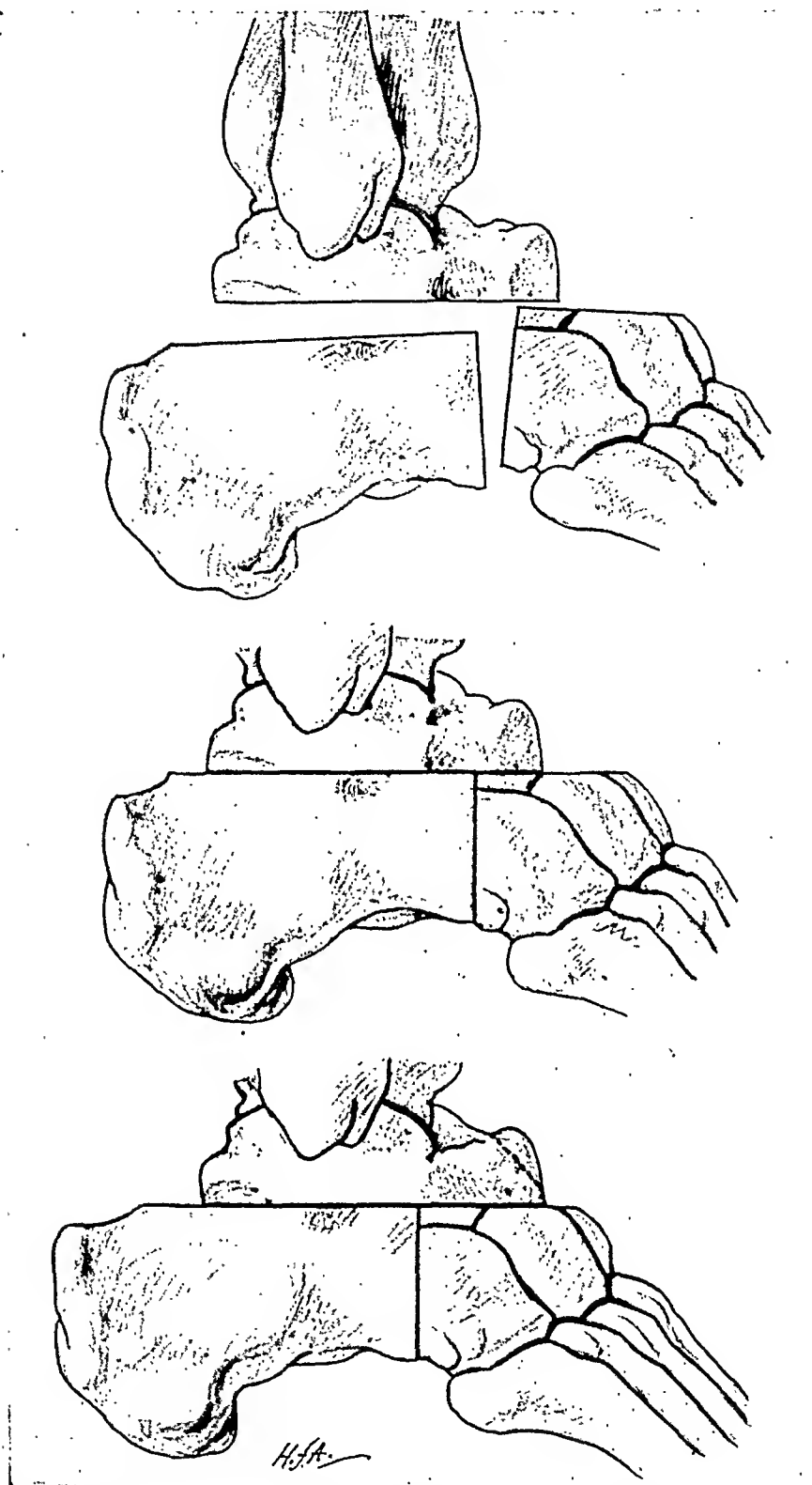
Fig. 2. Diagrammatic drawings showing sections of bone removed and displacement of the foot backward. (From MacAusland, in *Ann. Surg.*, 105: 452, 1937.)

not sufficiently ossified to ensure a bony ankylosis. This operation, as any reconstructive procedure, is more easily carried

formity should be corrected, insofar as possible, by manipulative and minor surgical procedures.

FIG. 3. Calcaneovalgus deformity before subastragalar arthrodesis. (From MacAusland, in Ann. Surg., 105: 452, 1937.)

FIG. 4. Solid arthrodesis six years after operation. Note the backward displacement of the foot. Same case as Figure 4. (From MacAusland, in Ann. Surg., 105: 452, 1937.)

ont in the child, although it may be adapted successfully to the adult.

No paralytic foot should be stabilized until at least two years have elapsed from the acute attack.

Operative Technique (Figs. 1 and 2). Before this arthrodesis is undertaken, de-

A semicircular incision is made on the outside of the foot, beginning over the dorsum in the midtarsal region, curving under the external malleolus, and ending over the Achilles tendon. The incision is carried sufficiently below the astragalocalcanean joint to avoid cutting the ex-

ternal ligaments between the astragalus and the fibula. The skin and fascia are dissected back.

The dorsal extensor tendons are retracted. The peroneal tendons are severed close to their attachments and retracted. Long sutures are placed in their ends. The astragalocalcanean ligaments are severed. The capsule over both the astragaloscaphoid and the astragalocalcanean joints is opened.

If cavus deformity exists, the next step is to remove a v-shaped wedge from the calcaneocuboid area, with its apex toward the plantar side. Just enough bone is excised to allow correction of the deformity. If no cavus deformity is present, this operative step is unnecessary.

The ligaments on the inner side of the astragalus are dissected upward in order that the entire body of the talus may be carried into the wound. Care should be taken in so doing not to damage the ligamentous attachments of the astragalus and the tibia and fibula.

A small section of bone, from $\frac{3}{8}$ to $\frac{1}{2}$ inch in thickness, is removed from the lower surface of the astragalus. This piece of bone is thicker on the inner or outer side of the astragalus, depending upon whether valgus or varus deformity is being overcome. A section of bone, of corresponding size, is removed from the upper surface of the os calcis.

The os calcis is brought into relation with the astragalus, thereby closing the wedge that has been made to correct the cavus deformity. If the relations are satisfactory, the surgeon, using a saw, cuts through the scaphoid and tarsus on a plane with the cut surface of the os calcis. The released section of bone is removed.

The foot is displaced backward. Any remaining bulge on the upper surface of the astragalus is shaved off.

The peroneal tendons are transplanted and fixed at the attachment of the Achilles tendon.

The wound is closed in the usual manner.

A plaster of Paris cast is applied, extending from the toes to above the knee, with the knee flexed at an angle of 45 degrees,

Fig. 5. Weight-bearing, with the transplanted peronei supporting the full weight of the body. Same case as Figures 3 and 4. (From MacAusland, in *Ann. Surg.*, 105: 452, 1937.)

and with the foot in approximately from 5 to 8 degrees of plantar flexion. Care is taken while the cast is being applied to maintain the posterior displacement of the foot by pressing it back on the tibia and fibula. While the cast is drying, it is well to keep the bottom of it flat by means of splint wood.

The leg is kept elevated for about three weeks. The cast is then removed, the leg is extended, and a new plaster cast is applied extending from the toes to below the knee, and with the foot at the right angle to the leg and in slight valgus. Weight-bearing is allowed in another three weeks. The plaster cast is removed on the tenth week after the operation. Protection is provided by a shoe that is equipped with an outer upright and a stop joint to maintain the

correct position and limit motion. Physio-therapeutic measures are instituted, and gradual use is begun.

one of the first cases that was operated upon, and the result was due to inaccurate technique. (Figs. 3, 4, 5, 6, and 7.)
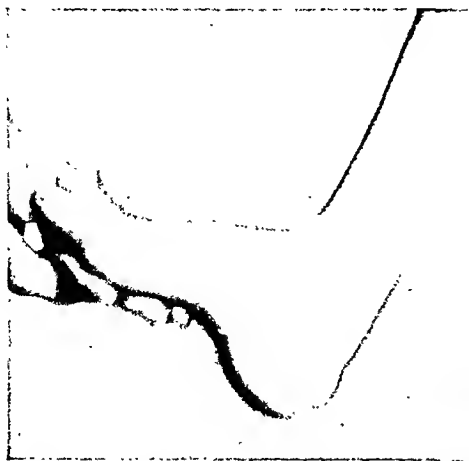
FIG. 6. Calcaneocavus deformity before operation. (From MacAusland, in *Ann. Surg.*, 105: 452, 1937.)

FIG. 7. Same case. Foot in corrected position, eleven years after subastragalar arthrodesis. Patient walks well without a limp. (From MacAusland, in *Ann. Surg.*, 105: 452, 1937.)

End Results. This operative method of arthrodesis has been carried out in twenty-one cases. It has been possible to trace sixteen of these cases. The time between the operation and the final examination ranged from two to thirteen years. In five cases, over twelve years had elapsed; in seven cases, over six years; in one case, five and a half years; in two cases, two and a half and three and a half years respectively; and in one case, two years.

Eleven cases were in children between the ages of ten and eighteen years. One child had had arthrodeses of both feet. Four patients were young adults.

Calcaneocavus deformity was present in five cases, and calcaneovalgus in six cases. In a group of three cases, among which was the bilateral case, the foot was in valgus deformity. Two patients had flail feet.

All but one patient obtained a good result, the foot having excellent stability, and the patient being able to walk well without support. There was no complaint of pain. The odd patient was handicapped by contraction of the great toe, and she walked with the foot in varus deformity. This was

SUBASTRAGALAR ARTHRODESIS IN JOINT DISEASE AND INJURIES

Indications. In old fractures of the subastragalar region, and particularly in fractures of the os calcis, in which bony changes have taken place at the subastragalar joint, or in which there is strain from faulty mechanics, arthrodesis is indicated to lessen the disability. The foot is painful and limited in motion, and it is particularly difficult for a person with such a foot to walk upon uneven ground. Not infrequently a dislocation accompanies the fracture, with the result that the joint is under further strain from deformity.

In infectious processes of the subastragalar joint, arthrodesis may be carried out to stabilize the foot. A tuberculous process of the joint may be checked by arthrodesis. An arthritic subastragalar joint may be stiffened to relieve pain. When a fibrous ankylosis has resulted from an infectious process, leaving the joint painful and subject to strain, an arthrodesis is indicated to produce a firm bony ankylosis.

Subastragalar arthrodesis may be used to advantage in connection with Chopart's amputation. Following amputation, there is a tendency for the Achilles tendon to pull the posterior part of the os calcis upward, with the result that the patient walks on the forepart of the bone and the stump. Bearing weight is painful. By arthrodesis of the subastragalar joint with displacement of the os calcis forward, better weight-bearing is established.

Operative Technique. Subastragalar arthrodesis in joint disease or joint injuries is carried out in the same manner as in paralytic cases, except that the foot is not displaced backward to the same degree. Slight displacement backward, however, is advisable to establish better balance.

CONCLUSIONS

Subastragalar arthrodesis alone or in combination with fixation of adjacent joints is an accepted procedure for stabilizing certain feet whose function has been disturbed through paralysis, disease, or injury.

The method of fixation presented by the writer fulfills the requirements of a subastragalar arthrodesis. In all cases solid fusion is ensured. In the treatment of the paralytic foot, provision is made for the correction of deformity, and better balance is established through backward displacement of the foot.

Twelve years of experience with this method has proved that it ensures permanent success. The patients have obtained stable, functional feet, and there has been no recurrence of deformity.

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AN OPERATION FOR THE CURE OF ACHILLOBURSITIS

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THIS operation was developed because of failures encountered after the usual surgical procedures.

FIG. 1. Relationship of the bursae to the os calcis and to upper quarter of patient's shoe. Shows how wedge is removed from the os calcis.

Etiology and Pathology. Achillobursitis is seen most frequently in women, since it is directly influenced by the pressure of the upper quarter of the shoe posteriorly and since women's shoes are necessarily more cupped to keep them on the feet because of the higher heels. There may be an associated rheumatic element.

Bursae occur anywhere in the body where there is irritating pressure against a bony prominence. At the heel, there are two bursae of importance near the point where the tendo Achillis inserts into the os calcis. One is deep and the other immediately superficial to this attachment. The superficial one is more commonly involved. Its walls become thickened by chronic inflammatory changes, fluid accumulates in the bursa, and occasionally suppuration occurs, but this is uncommon. With the increase in the local reaction, the walls of the bursa become adherent and the fluid disappears. The posterior superficial edge of the os calcis is frequently a sharp pro-

FIG. 2. After operation, showing the wedge closed and the superficial bursa removed.

jection. The overlying superficial bursa covers a much larger area than this edge—its center is lower. Due to irritation of the bone, there may be local new periosteal bone production.

Symptoms. The patient complains of a local painful swelling at the back of the heel near the attachment of the tendo Achillis to the os calcis. The swelling often projects more to one side of the tendo Achillis—usually the outer—and is slightly discolored. The pain is more marked when and often only when wearing shoes. The patients have tried different types of shoes without relief and may have had a portion of the quarter cut out of the shoe. Often there is a history of a previous unsuccessful operation.

The bursal involvement is secondary to local pressure against underlying bone. The condition may aptly be compared to a bunion. Removal of the bursa does not

correct the underlying cause and is inadequate. One would not remove the bursa in hallux valgus and consider this procedure

Operation. The operation has as its object the removal of the underlying bony prominence and incidently the excision of
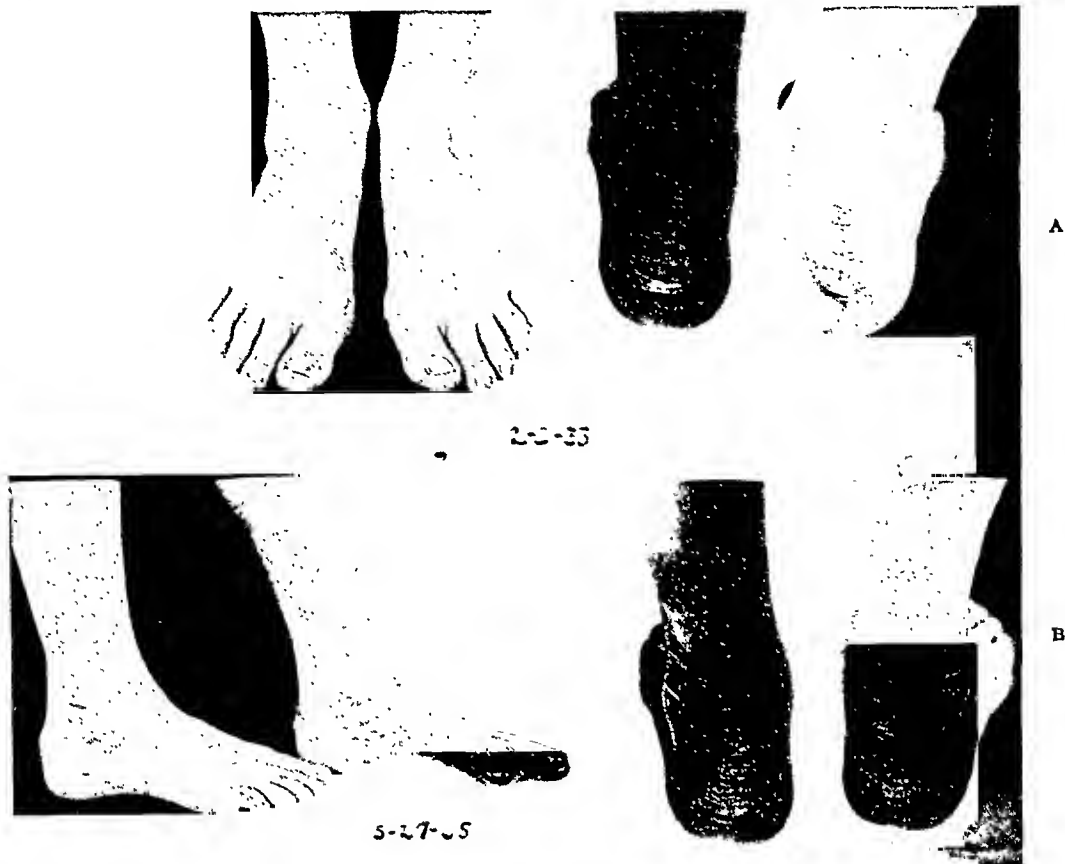
FIG. 3. C. R. A, before first operation. B, three months later and prior to second operation.

FIG. 4. C. R. Ten months after author's operation.

satisfactory; yet this is often done in achillobursitis without attacking the underlying bony deformity. Indeed it was this observation that led to the present study and the development of an operative procedure that has given uniformly complete relief.

the chronically inflammed bursa. The procedure is carried out under a tourniquet. While I have used a transverse incision, I find that a longitudinal incision about 2½ inches long, lateral to and parallel to the heel cord is more satisfactory. The bursa, a flat numismatic-shaped structure lying

immediately beneath the skin and superficial to the tendo Achillis, is readily isolated and removed.

FIG. 5. C. R. Above, after first operation. Below, after the operation described in text. X-ray taken while foot was in plaster of Paris.

Exposure is now carried down to the os calcis in front of the tendo Achillis by sharp dissection. If the os calcis projects as a sharp edge at its posterior superior surface, this is smoothed off with a small osteotome. This procedure is not sufficient for cure.

This brings us to the essential feature of the operation. The soft parts are peeled away with a periosteal elevator and a wedge of bone with base upward is removed from the os calcis at a point ½ to ¾ inch from its posterior border. The base of the wedge is about ¼ inch wide and extends through the transverse diameter of the calcaneum and two-thirds the distance through the vertical diameter. The line of

osteotomy is at a right angle to the superior surface of the os calcis and the apex of the wedge presents towards the sole. The posterior fragment of bone is countersunk by means of a bone set and mallet and its approximation maintained by a couple of chromic gut sutures passing through the heel cord and the periosteum of the os calcis in front. The subcutaneous tissues are closed with plain catgut and the skin with silk. Plaster of Paris casts are then applied from the toes to the knees with the feet in slight equinus. A wedge of felt is applied under the heel to compensate for the equinus attitude and after a couple of weeks, the patient is allowed to walk with crutches. Support is maintained for five weeks. This procedure does not disturb the original smooth posterior covering of the os calcis.

ILLUSTRATIVE CASES

C. R., age 22, female, was first seen by me on May 29, 1935. She complained of pain in the back of both heels which had existed for two years. This pain was aggravated by walking and also by the pressure of her shoes.

My examination showed there was soft part swelling superficial to the tendo Achillis and protruding on each side of the tendon near its attachment—obviously the superficial type of bursitis. In addition, unusual bony thickening was evident at the os calcis beneath the soft part swelling. This was more marked on the lateral aspect.

On February 8, 1935, the bursae near the attachment of the tendo Achillis had been removed from both heels. At this time it was realized that there was a bony prominence at the posterior superior border of the os calcis on both sides. These excrescences of bone were removed at the same time. This operation did not give the hoped for relief.

On May 31, 1935, the operation herein described was performed through a transverse incision.

Several weeks after the operation, the patient's soles showed blisters due to dermatophytosis. This dermatologic condition was treated by the application of gentian violet.

The further course was uneventful. She was completely relieved of the pain in her heels.

M. G., age 22, female, was first seen by me on February 5, 1936, because of painful swelling about both heels, particularly when wearing

discoloration. There had never been any suppuration.

One year previous, "cysts" were removed

Fig. 6. C. R. Appearance of os calcis ten months after operation.
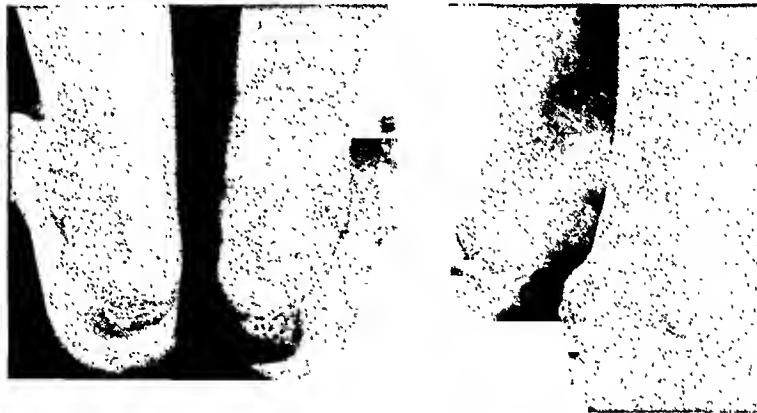
Fig. 7. M. G. One year after removal of bursae elsewhere; prior to author's operation.
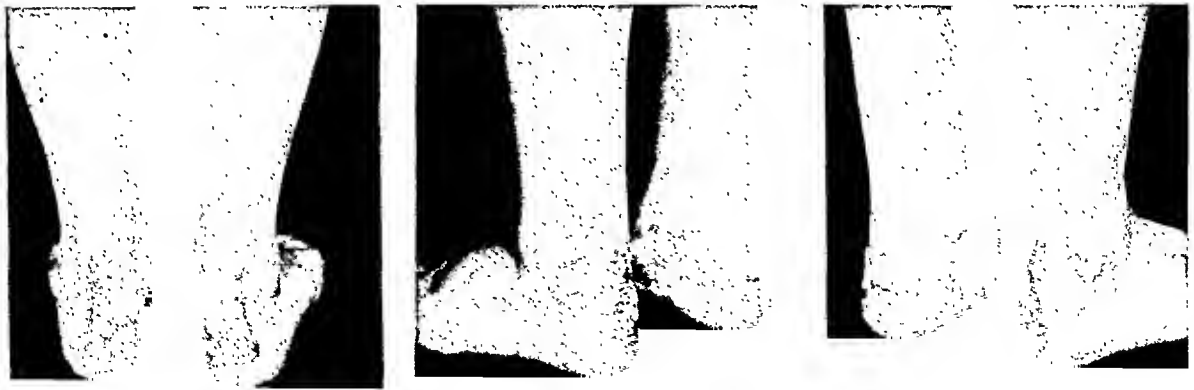
Fig. 8. M. G. Eleven months after author's operation.

shoes. The condition had existed for six years, its onset having coincided with the wearing of high heeled shoes. The swelling showed local

from both heels. The wound on the left "broke down." Two months after the operation, the swelling in both heels had returned.

Examination showed swelling and thickening near the attachment of the tendo Achillis. There was local sensitiveness but no inflamma-

bit dusky. Operation was advised but was deferred.

The patient returned April 5, 1938, unre-

FIG. 9. I. S. A, before operation. B, seven months after operation.

tory signs. There seemed to be bony resistance beneath the bursae but this was not confirmed by x-ray examination which showed the soft part swelling. Dorsal flexion of both feet was limited.

On February 7, 1936, the patient was operated upon. Each heel was exposed through a longitudinal incision lateral to the heel cord. The superficial bursae were removed, then the wedge of bone removed from the os calcis as described in the text, and the posterior fragment countersunk with a bone set and fixed with chromic gut sutures passed through the tendo Achillis and periosteum of the os calcis. Plaster of Paris casts were applied with the feet in slight equinus. After ten days, the patient was discharged from the hospital walking with crutches.

The bursae on microscopic pathologic examination showed chronic inflammatory changes.

On March 18, 1936, the casts were removed, and the wounds were found healed by primary union. The sutures were removed. The patient's further course was uneventful.

I. S., age 21, female, was first seen by me on April 5, 1935, because of painful swelling on the backs of her heels which had been present for six years. At times, the swelling discharged thin material. The patient had tried simple local measures without relief.

She showed a bilateral achillobursitis of the superficial type with skin over the swelling a

lieved and requesting operative intervention. Her condition was unchanged.

X-ray examination showed the posterior superior edges of the os calcis in both feet rather sharp.

On April 9, 1938, the heels were operated upon under tourniquets. A median longitudinal incision was used. The bursae were removed. The edge of the bone projecting superficially and posteriorly from the os calcis was chiseled off and the wedge of bone removed from the os calcis and the posterior fragment countersunk. Plaster of Paris casts were applied in slight equinus.

The postoperative course was uneventful. The casts were removed after a month.

Microscopic study of the bursae showed chronic inflammatory changes.

The patient's recovery was complete.

CONCLUSION

A simple operation is described for the relief of achillobursitis which is based on the underlying bony pathology and which leaves the original smooth covering of the os calcis projecting posteriorly. Removal of this posterior bony projection at the top of the os calcis is essential for cure of the condition.

I wish to thank Dr. S. Kleinberg on whose Service I treated the first two patients.

THE HISTORY OF BONE TRANSPLANTATION IN GENERAL AND ORTHOPEDIC SURGERY

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BETWEEN 1911 and 1916 Dr. Fred H. Albee of New York published about twenty articles on the utility and technique of bone transplantation, four in German, French and Spanish. The effect of these articles, and of many others which followed, upon surgical practice is so well known as scarcely to need to be mentioned. The groundwork upon which Dr. Albee's publications on bone graft surgery rested, provided both by himself and by his predecessors is, however, worthy of study and review.

The possibility of using various materials for the direct fixation of bone fragments in fractures had occurred to many early surgeons. Salmon (1697), speaking of gunshot wounds with fracture of the bone, says, "In the first place therefore, it is necessary that the great fragments of the bones be restored again into their places, that they may be joined together by a callus, but in the application of the splinters you must use great caution, lest by them you excite more pain than otherwise would be and so cause convulsions, inflammation or gangrene which by due care might not have happened."

Several excellent general reviews of this literature and some historical studies have already been made. One of the most valuable bibliographic contributions was that by Clarence A. MacWilliams.[1] As indicated by this collective review much of the literature preceding Albee's work, was devoted to a discussion as to the origin of bone growth and bone repair. Dr. MacWilliams devotes a good deal of space in his article to that debate.

Special credit must be given to the foundation work on bone surgery by Macewen in England and Ollier in France, as well as by Nussbaum and Lexer in Germany. Gangolphe says that Ollier was the first to transplant bone under the skin not in contact with bone.[2] Already in 1859 he had reported to the Académie the exchange of segments of the radius in rabbits from one foreleg to the other. Attention is directed by him to the greater success of autoplastic (autogenous) grafts, but transplants from animals upward in the scale of species (chickens to rabbits, rabbits to human beings, etc.) had succeeded. Gangolphe refers to the success of "greffe massive ou fragmentaire" and says "la question des greffes osseuses n'est pas encore complètement élucidée, et que la série des recherches entreprises depuis Ollier ne peut être considérée comme absolument close. Peut être, grâce à certaines conditions, la greffe hétéroplastique [heterogenous] poura-t-elle, à l'avenir, rendre de plus fréquents services que dans le passé."

Ollier's first discussions on this subject from 1859 were included in his book on resections of bone and joints in 1885. His long series of studies and writings cover the whole field and the entire period up to 1897. To many of his ideas regarding the histology, pathology and growth of bone, we are indebted for the basis upon which we rest our modern procedures.

The modern slide graft for bridging defects in the long bones was anticipated by Nussbaum in 1875. On April 10, in the *Zentralblatt für Chirurgie,* he advocated rotating a fragment still attached at the lower end of the tip so as to bridge a defect in the ulna and fastened across a 2 inch defect in about the same manner as the slide graft used at present. This patient

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[1] *Surg., Gynec. & Obst.* (Jan.) 1916.

[2] *Maladies des Os,* page 66. Paris, 1894.

with a firm radius but a serious defect in the ulna recovered in a few weeks and got a useful arm.

At the same time Nussbaum was suggesting osteotomy by cutting part way through a bone through a small incision. Then, after healing of the skin wound had been obtained, he fractured the shaft. In this way he could obtain correction of angulation or other deformity in a limb after sound healing otherwise. This obviated the dangers of manipulation and correction at the same time as the open operation.

It is interesting to note that the article published in Germany on April 10, 1875 was thoroughly abstracted in the *Medical Times and Gazette* in London on April 24.

Macewen's earliest observations and reports were published in 1881. At that time he was employing small fragments of human bone, obtained from osteotomies, for transfer to a partially destroyed humerus. By this means he succeeded in building up a complete bony union and repair and obtained a useful arm.

While his was a very different technique from that employed in most subsequent procedures, Macewen was establishing the principle that bone could be transplanted and would grow to produce a satisfactory repair of bone defects.

In the section on bone grafting in Heath's Dictionary of Practical Surgery (Philadelphia, 1886), Sir William amplified some of the views expressed in his earlier articles. He suggested that human bone might be obtained for bone graft purposes from amputations in hospitals. He pointed out, as in his previous writings, that preservation of the periosteum in obtaining such material was not essential. He did think, however, that to leave the periosteum on protected the underlying osteoblasts and assisted in the formation of vascular connections when the transplant was made.

His argument was for the transplantation or the implantation of small fragments about the size of a pea. He emphasized the preparation of the operative field according to the Lister method, and pointed out that the limb upon which the operation was being performed should be fixed and kept in a position of rest following the operation.

H. Bircher of Berne[1] advocated the use of intramedullary ivory pegs. He also suggested the locking of fracture fragments with an $\simeq$-shaped graft such as has been suggested by more recent writers as an original procedure. Bircher advocated the early operation upon simple fractures and reported five successful cases.

Howard Marsh of London[2] reported nine successful cases where bone knitting needles were used to pin tibia and femur together after resection of the knee. Mr. Marsh pointed out that the control of the upper end of the tibia and the lower end of the femur had presented so many difficulties and so many unsatisfactory splints had been tried, that he recommended direct fixation in this way. After driving the knitting needles up through the tibia into the femur he cut them off close to the bone and enclosed them by suturing his wound after the splint had been successfully applied. In the nine cases, all healed and gave satisfactory results.

The numerous references to Poncet of Lyons, France, refer to his attempts to treat a compound un-united fracture of the tibia in May 28, 1887. Poncet used only the first phalanx from the toe of an amputated leg and while he reported that the bone graft healed in, he failed to get union of the fracture fragments. In the light of our recent experience this is easy to understand because his graft was obviously too small to have any effect in immobilizing the fragments or to provide sufficient surface for successful healing.

Adamkiewicz in 1889 concluded that small pieces of bone would reunite if they were replaced after removal by trephining. He said that exposure to air or treatment by carbolic acid did not impair the result. Among the points he mentioned were that osseous structures should come in contact,

[1] *Arch. f. klin. Chir.*, 34: 2, 1886.
[2] *Brit. M. J.*, Feb. 19, 1887.

but that they need not fit accurately. He thought the periosteum took no active part in the process of repair, but that the cellular connective tissue which formed became ossified. It is significant that he spoke of the growth of bone proceeding from the periphery surrounding such bone transplants.

One of our pioneers in orthopaedic surgery in New York, Dr. A. M. Phelps, reported in the *New England Medical Monthly* and in the *Medical Record* of February 21, 1891 an unusual early experiment in bone graft surgery. Dr. Phelps undertook to employ a pedicle bone graft which remained attached to the leg of the dog from which he was borrowing bone, and inserted into the leg of a boy with a defect in the tibia. The limbs of the boy and the dog were kept in relationship by splints and bandages for eleven days. At the end of that time failure to control the limb of the dog perfectly had resulted in some jerking and twitching of the graft, which remained loose although the soft parts had partly healed.

At that time Dr. Phelps cut loose the pedicle from the dog and found that circulation had been maintained. An eventual union of the graft was not obtained, and the bone had to be removed. The transplant, however, did show signs of growth both on the cortex and in the medulla and Dr. Phelps thought that success along similar operative lines might subsequently be obtained.

Dr. B. F. Curtis at St. Luke's Hospital in New York reported a case of bone transplantation for un-united fracture of the tibia in the *Medical Record* of January 2, 1892. He took out a section of the fibula and pushed it across practically subcutaneously into a defect of the tibia where it healed in. The man was bearing weight on the limb two months after the operation. The following year, in July 1893, Dr. Curtis published a paper in the *American Journal of Medical Sciences* with a rather careful study of the whole question of bone implantation and transplantation. He re-

ported four additional successful cases and evidenced a fairly thorough appreciation of the principles involved in bone graft work. He did, however, argue against the use of large grafts as he felt they could not be inserted so successfully and were more likely to undergo necrosis and have to be removed. Historical sources cited by Dr. Curtis were Kummell and Le Dentu and numerous items of the literature were referred to.[1]

Following the successful use of metal nails by Nicolaysen in hip fractures in 1897, Gillette of St. Paul, Minnesota was nailing hips in 1898 and G. G. Davis and H. A. Wilson in Philadelphia in 1907. Dr. Gillette used bone pegs at that time.[2]

Lexer began his publications upon the subject in 1907. They have extended throughout the recent period of research along with those of Albee and other modern writers. Lexer's greatest interest has been in the transplantation of entire joints, in which some interesting demonstrations but no striking human successes have been obtained.

Although Dr. Albee had done some experimental work, he did not concern himself too greatly about the source of the reparative processes, either as to the parent bone or the bone graft. One of the points discussed in Albee's early presentations, however, had to do with the merits of spine fusion without a graft and spine fusion with a transplant from another bone. Dr. Hibbs had proposed direct fusion by removing the intervertebral articulations. Dr. Albee pointed out that the osteogenic power of certain portions of the vertebrae was too low for them always to be trusted with the formation of a satisfactory fusion. The subperiosteal

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[1] *Deutsche med. Wchnschr.*, 17: 389, 1891. BUSCARLET. *Gaz. des hôp.*, 64: 1361, 1891. McGREGOR. *J. Anat. & Physiol.*, 26: 220, 1891; contradicted by Schmitt. *Arch. f. klin. Chir.*, 45: 401, 1893. SHERMAN. *Pacific M. J.*, June 1889. McGRAW. *Internat. Med. Magazine*, 1: 572, 1892. PONCET. *Lyon med.*, 1886, No. 39. BUCHANAN. *M. & S. Rep.*, 67: 526, 1892. McGILL. *Lancet*, Oct., 1889. FORGUE. *Congr. franç. de Chir.*, Tr. v: 617, 1891.

[2] *Med. Rec.*, Aug. 13, 1898.

insertion upon the laminae and the spinous processes of the tibial graft seemed to most of us to furnish a more secure foundation for bone growth and spine fusion, than the purely local spine procedure.

Two factors, along with Dr. Albee's extraordinary industry in this field, have been largely responsible for the great success of bone graft surgery. These were the introduction about 1915 of new and better electrically driven bone instruments, called by Dr. Albee "the bone mill" and the insistence by him of precise methods, not only of surgical technique, but in the cutting and implantation of all kinds of autogenous and other bone grafts. Henderson proposed the use of the patient's own bone, not only for grafts, but for machine-cut screws to be put into threaded openings in the receiving bed and the graft.

From the standpoint of the after-care of the patient following bone graft operations a contribution of major importance has been skeletal fixation of the bones by means of pins in plaster of Paris casts. The present writer does not approve now of ice tongs, wires, or other less efficient devices, especially when employed with apparatus that depends upon bars, bolts, screws, subject more or less to the whims of the patient or his attendants.

Many failures of bone graft procedures have been observed in which too much reliance was placed upon fixation and control by grafts too small or plates inadequately applied. After operation, too, limbs are often imperfectly controlled in plaster of Paris or other splint devices.

The larger grafts employed by Dr. Albee himself, by M. S. Henderson (massive grafts) and Willis Campbell (onlay grafts) have all contributed to an improvement in this respect. A further addition, however, by the writer and others is the use of skeletal pins at points remote from the operation and with the projecting ends fixed in the plaster of Paris cast. These maintain really fixed length and position, and add considerably to the percentage of good results.

It appears that much time has been wasted in trying to decide how many or what cells in the parent tissue or in the graft are responsible for ultimate union in fractures. It is entirely conceivable, as some have maintained, that the graft itself furnishes no osteogenetic factors and that all bone growth proceeds from the receiving portions of the bone. However, the apparent viability of some grafts and their participation in the repair process appears to be so convincing that it seems quite likely that at different times and under different circumstances grafts and the parent bone participate in different degrees in contributing to the success of this surgical procedure.

One point upon which the present writer has been engaged for many years and which has apparently not been taken into consideration by many operators is that the fitted graft has contributed so much to anatomic restoration, not only of the bony structures, but of the surrounding soft parts. When a bone graft is used to approximate and immobilize fracture fragments the adjacent nerves, blood vessels, lymph channels and other parts are put into the best position and maintained in the best relationship for physiologic function in the entire part or extremity. Such a contribution is of great importance to the patient's defense against infection and his recovery.

Another point of importance is that both the preoperative preparation of the surgical field and the postoperative care of the patient are essential to success. It should be remembered that a surgeon who is not a competent clinician and who has not treated fractures successfully by other methods, will find great difficulty in the surgical treatment. A mere technician is likely to lack consideration for the clinical features surrounding a fracture or other bone graft procedure and to disregard some of the pre- and postoperative requirements of the patient.

The successful use of protective splints or plaster of Paris following surgical

procedures of this kind should be available to every patient. The present writer has been emphasizing for many years the importance of restoration of anatomic relationship and immobilization in correct position for the prevention and cure of local infection, metastasis and septicemia. The careful selection of preoperative conditions, the successful performance of the surgical procedure and the best possible clinical after-care of such patients is a combination essential to success in all bone, joint, and bone graft surgery. Excellent splinting in good length and position for the entire extremity is essential for the control of the limb, to secure rest for the patient and to protect him against irritative motion which predisposes to infection and in other ways militates against a good result.

In those patients in whom there has been a long period of non-union with eburnation of the fragments, all of these expedients must be employed with great skill and precision. In congenital pseudoarthrosis, for example, there are apparently no osteogenetic cells near the ends of the un-united fragments at all. In these cases very long grafts extending back into the portions of the bone where osteogenetic cells may be found and perfect control of the fragments for a long time in good length and position is necessary.

Dr. Albee has practiced very extensive architectural reconstruction in those cases in which there has been failure to regenerate an entire diaphysis or in which large portions of bone or even joints have been removed on account of malignancy. Some of Dr. Albee's procedures along these lines have set an example for other surgeons, which has enabled them to make important contributions to patients in extreme cases. All of these procedures mostly suggested or originated by Dr. Albee have contributed to widening of the field for bone graft operations.

The earlier studies of bone growth and bone repair by Macewen and others considered in the light of our more recent experience, show that there was often failure to appreciate the importance of correct relationship of the parts, including the bones entering into the formation of the limb. Some of the propositions advanced by Macewen in his article in the *Annals of Surgery*, 1887, show that he did not recognize the possibility of incomplete or only partial destruction of the cellular osteogenetic tissues in the vicinity of inflammatory lesions. He did not seem to appreciate the possibility of reconstruction by cells or tissues only partly damaged and circulation supplied from a distance. The possibility of cells traveling along the only temporarily damaged bony tissue just as they do along grafts of boiled or even living bone was not mentioned.

Moreover, it is a fact that periosteal separation and reunion may occur, even after inflammatory products have apparently inflicted more damage than actually occurs. Some of these points have confused the issue in discussing the fate and conduct of bone grafts and the entire question of bone growth.

It is quite obvious that some of the operators who thought they were transplanting bone without osteogenetic cells actually did carry along such cells with their grafts.

On the other hand, the residence of osteogenetic cells in other portions of the bone, even though unrecognized microscopically or otherwise, might have contributed to the formation of all the new bone. In such cases one or several agencies contribute to the viability of the graft apart from demonstrable microscopic appearances or other evidences of growth and repair.

Dr. Albee and some other observers have gone ahead with their program of bone transplantation or implantation without worrying too much about these details and have had a high percentage of successful results. Too much emphasis has been, sometimes, placed on the work of the surgeon and the appearance of the graft and too little upon the resources of the

patient. That this same neglect has been apparent in dealing with infections, both in bone surgery and in the matter of infected wounds, is a point that has been emphasized by the present writer. Provision of conditions suggested above with protection against new infection (especially by infrequent dressings) will often enable the patient to perform wonders of healing and cure that are beyond our comprehension or explanation.

It is to be hoped that we may learn later more about the chemistry and physiology of bone formation and repair and that when we do have a better knowledge of tissue and body fluid chemistry, we may clarify our views regarding defense against infection and repair. Also when we know more about the physiologic chemistry of resistance to infection and tissue repair, we may be able to use chemicals in wounds or intravenously in a rational way. At present we are still entirely unable rationally to do so.

On the clinical side, as suggested above, the bone graft operation has made an enormous contribution to fracture, bone and joint tuberculosis, and other kinds of deformed or potentially deformed or disabled patients. Much of this progress has been empirical. On the technical side the greatest credit is due to Dr. Albee. For preliminary study credit must be given to Ollier, Macewen, Curtiss, Lexer and many others as indicated in the attached bibliography. To no one since 1911 however, so much as to Dr. Albee is due the benefit to patients and the advantages to surgeons accruing from the success of the present methods in bone graft surgery.

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Pneumococcal peritonitis is practically confined to young female children under the age of twelve years.

THE TREATMENT OF COMPOUND FRACTURES

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IN this automotive and industrial age, compound fractures are becoming more and more frequent. The problem of how best to treat them has been before surgeons since the beginning of our art and there is little new to be added. However, with the frequency and seriousness of this accident, we should endeavor to establish certain basic principles which would govern the routine treatment. Each case presents a specific problem; no two cases are exactly alike, and treatment should vary according to the operating surgeon's judgment and experience. That such treatment is not in any way standardized can be determined by comparing the procedures advocated in the various textbooks and in surgical periodicals by supposed authorities. There is a babel of advice and opinion, so that the general practitioner and general surgeon are at a loss to know what to believe. It is the general surgeon and general practitioner who treat 99 per cent of these cases primarily. The man who sees the case in the first twelve hours determines the success or failure in the outcome. The orthopedic specialist sees the late failures and attempts to salvage what he can from the wrecked limb.

The general principles of treatment today are exactly those advocated over one hundred years ago by Sir Astley Cooper. With no knowledge of the nature of sepsis, with only the dictates of common sense and the experience gained by careful observation, he formulated the principles of gentle cleaning of the wound with soap and water, débridement, no meddlesome dressing, immobilization, and rest. To quote him, "The arrest of hemorrhage is the first object. . . . The extremity of the bone is to be washed with warm water, as the least extraneous matter admitted into the joint

will produce and support suppuration; and the utmost care should be taken to remove every portion of it adhering to the end of the bone. If the bone be shattered, the detached pieces are to be removed; but this is to be done in the most gentle manner possible so as not to occasion unnecessary irritation. When the bone has been reduced, a piece of lint is to be dipped in the patient's blood, and applied wet over the wound, upon which the blood coagulates and forms the most natural, and, as far as I have seen, the best covering for it. In four or five days if there be much inflammation, a corner of the lint should be lifted from the wound to give vent to any matter which may be formed, but this ought to be done with great circumspection, as there is a danger of disturbing the adhesive process if that be proceeding without suppuration." In a case report he says, "As the parts were in a tranquil state, the dressing was not disturbed for four weeks." These simple principles have been and are overlooked in the constant changing from fad to fad. Every known antiseptic, every color of dye, every new method of fixation, physiotherapy of various sorts, all have had their advocates and brief hour of popularity. To trace the history of these methods and their comparative merits would be tedious and useless. We will describe the routine treatment which has given us the best results and which we believe to be basically sound.

The treatment of compound fractures should begin at the scene of the accident. If it were possible to give these patients proper first aid treatment, the results would be infinitely better. A hypnotic should be administered at once, hemostasis established, the wound cleaned and a sterile dressing applied. Adequate splints should be provided or traction in a Thomas arm

or leg splint, and careful transportation should be arranged. The fracture committee of the American College of Surgeons is doing admirable work in this matter, but the surface has scarcely been scratched. About one fracture in one hundred receives adequate first aid treatment; the others do not and will not until every highway patrolman, every ambulance driver, and, sad to say, every physician is equipped and knows how to give this service. The present conditions constitute one of the black marks against our profession.

At present we may consider that treatment does not begin until the patient reaches the accident ward. There he should be given morphine immediately, hemorrhage should be stopped and tourniquets removed. Examination is then made for other injuries, fractured skull, other fractures, injury to kidney, bladder or abdominal viscus. Simultaneously with the examination, treatment for shock is begun. No manipulation or operative procedure should be undertaken which might increase the degree of shock or impede the patient's recovery, but it is a mistake and a frequent one to wait until the patient "comes out of" shock before doing anything for his fracture. It is very easy for an attending surgeon, when called at 2 A.M. and told by the intern that there is a compound fracture in with mild degree of shock, to say, "Treat him for shock and I'll see him in the morning." Almost without exception, the treatment for shock and the treatment of the fracture can proceed simultaneously with advantage to both. Morphia, heat, position, blood transfusion can be given without interfering with the treatment of the fracture. In fact, we believe that reduction of the fracture and secure immobilization are part of the treatment for shock. These measures stop pain, allow no further tissue damage, and improve the circulation in the limb, all of which tend to counteract shock.

If the patient is able to be moved, the limb is splinted and he is taken to the operating room at once. If he is in shock, the wound is given a preliminary cleaning and traction is applied with a well padded Thomas splint. As soon as his condition is such that he may be moved and an anesthetic given, he is taken to the operating room.

On reaching the operating room, the patients, without exception, are given an anesthetic. For the lower extremity, spinal, 50 to 75 mg. of novocaine in 1.5 c.c. of spinal fluid is the anesthetic of choice. For the upper extremity, a general inhalation anesthesia or brachial block may be used. Under anesthesia, the temporary splints are removed and traction maintained by an assistant. Sterile gauze is placed over the wound and the surrounding skin area cleaned by scrubbing with soap and water, alcohol, and ether. The gauze is then removed and the wound scrubbed gently with soap under a continuous stream of water. By placing the irrigating tube in the wound and using a continuous stream of water, the current is from the depths of the wound outward, and there is no danger of carrying dirt into the wound. Surgical asepsis is only as strong as its weakest link, and we could never see the logic of scrubbing the hands eight minutes, protecting them with gloves, and then preparing the dirty skin and wound by dabbing on some confidence-inspiring, brilliant hued antiseptic.

We also are convinced that this whole procedure should be carried out no matter how small the communicating wound and whether it is made from within out, or from without in. It is a temptation to apply an antiseptic and dressing to these small puncture wounds and treat them as closed fractures. The size of the external opening bears no relation to the extent of the underlying damage. On enlarging some of these innocent looking punctate wounds, one frequently finds foreign bodies—bits of stocking, dirt, grease, as well as macerated and devitalized tissue. Once having done this, one is reluctant to rely on the appearance of the external wound and dab a little antiseptic on the surface and treat the case

as a closed fracture. Results bear this out; even in the puncture wounds, the percentage of sepsis is less if the wound is thoroughly prepared and debrided.

After the skin and wound have been cleaned, the skin is painted with iodine or tincture of metaphen. Formerly we poured an antiseptic in the wound, but we believe the damage done to the delicate, exposed tissues far outweighs the advantages. One never thinks of pouring iodine into a clean herniorrhaphy wound, and our object is to convert these wounds into surgically clean ones, and to a large measure we succeed. The wound is draped, gowns and gloves changed, and the débridement proceeds. In débridement we must be conservative, but thorough. The radical débridement practiced during the World War is needless and harmful and has been abandoned. A strip of skin 0.5 cm. in width is excised around the margin with a sharp scalpel. This scalpel and forceps are replaced with clean ones and all devitalized and soiled tissue carefully removed by sharp dissection. Small fragments of bone which are entirely free are removed or, if numerous, are removed, scrubbed, and replaced. Any large fragment, or any fragment with part of its periosteal attachment intact, is better left in place. If the ends of the bones are soiled, as is frequently the case, the soiled bone is bitten off with rongeurs. The wound, during and after this débridement, is gently irrigated with warm water or saline.

Exact hemostasis is established by ligating the vessels, and vessels only, with ooo or 5-o catgut, or, in the cleaner wounds, fine silk. Mass ligature of tissue is not permissible. The strangulated tissue will act as a foreign body and culture medium and sepsis almost inevitably result.

We are now faced with a clean wound and a fracture. Our first problem is how to treat the flesh wound. Shall we close it tightly, close it loosely, drain it, pack it open, or treat it by the Carrel-Dakin technique? No hard and fast rules can be laid down; however, here are our own principles of procedure. In wounds debrided within about six hours after the accident, and in which there has been little destruction or crushing of tissue, it is safe to close the wound with interrupted sutures. If the wound cannot be closed without tension, releasing incisions are made parallel to the wound and about 1½ to 2 inches distant. These wounds are left open and occasion no trouble. The fracture is then treated as a closed simple fracture.

If the debridement is done after about six hours, or if we do not believe that the mechanical cleaning has been effective, or if there is much contused, crushed tissue, or if the blood supply has been materially interfered with, we prefer the Orr procedure. The Orr method introduces no new principles of treatment of the compound fracture, but it is a detailed method of applying well established principles. Dr. Orr bases his treatment on the following basic factors in wound healing: (1) primary asepsis or antisepsis; (2) adequate drainage; (3) immobilization of injured parts; and (4) protection of wounds against disturbance and reinfection. In the Orr method, after the débridement, the entire wound is packed lightly with vaseline gauze. The vaseline gauze goes down to the bone and no pockets are permitted in the wound. The object is to secure perfect wide open drainage from all parts of the wound. Over the pack and skin edges, strips of vaseline gauze are placed and a moderate sized gauze dressing. A snugly fitting, lightly padded plaster circular casing is then applied, immobilizing at least the joint above and joint below the fractured bone. No splitting or fenestrations are permissible. No dressing is done, and the casing is not removed for from four to six weeks. The patient is encouraged to ignore the odor. This characteristic, peculiar odor is due to the decomposing blood and wound secretions and is not highly objectionable. The treatment, and reasons therefor, should be carefully explained to the patient and family, else they will believe they are being neglected and go to a surgeon who

will "take such good care of them" that he dresses the wound two or three times a day and paints it or irrigates it with this and that dye or antiseptic. It is hard for doctors, much less laymen, to believe that we do more harm than good meddling with wounds, and that wounds in skin, flesh, or bone heal best when put at rest and not disturbed.

After four to six weeks the casing and dressing are removed. It will be found that the granulations will have pushed the packing up from the bone and the depths of the wound. If and when there is a good, firm base of red healthy granulation tissue, the area is covered with the deep pinch grafts of Davis. Over the grafts a paraffin mesh gauze and a pressure dressing are applied. The limb is then placed in another circular plaster casing. These grafts will give a tough, movable skin far better than the fragile scar tissue epithelium which will cover the area if it is not grafted. The plaster casings are changed every three to five weeks until solid bony union is obtained.

We believe that the results of the Orr method are incomparably better than those obtained by leaving the wound open and irrigating with Dakin's solution or other antiseptics. The patients are more comfortable since they are relieved of the dreaded, painful dressings. The fracture is more securely immobilized, and there is no chance of introducing new infection. The theoretical objection that anaerobic infection is more likely to develop is not borne out in practice.

In the treatment of these wounds we use only these two methods. There can be no compromise, no intermediate ground. The wound must be closed, or it must be left completely open. The insertion of a drain because there is oozing, or to allow the escape of serum, invariably results in an infected wound. We do not even agree with Cotton who advocated loose closure. Loose closure means pockets or dead spaces, and, while we do not attempt hermetically to seal these wounds which we suture, we try to bring the parts together in exact apposition without tension.

The only compound fracture wound in which we still use the Carrel-Dakin treatment is in extensive crushing injuries of the thigh. Here there are large muscle masses partly devitalized, and a complete débridement is not always practicable. These wounds are conservatively debrided, left open, and treated by the Carrel-Dakin technique, except that irrigations are given with azochloramide every twelve hours instead of every two hours with Dakin's solution. The Carrel-Dakin technique is worse than useless unless it is carried out exactly and completely as described by Dr. Carrel, and in civilian hospitals this is almost never done. Azochloramide attains the same effect with much simpler technique.

Fractures of the femur are the only ones we treat by traction suspension. All others requiring traction are treated by fixed traction in plaster casings and even in the thigh, if infection and the nature of the wound permit it, we prefer fixed traction by placing a pin through the condyles and half pins in the trochanter and, after reduction, incorporating these in plaster.

The treatment of the fracture itself is not different from that of a simple fracture. We must secure good anatomic reduction and securely immobilize the limb for an adequate length of time. The method of doing this is of secondary importance. In the vast majority of cases the fracture can be reduced at the time of operation and the fragments made to interlock so as to maintain the reduction. If necessary, the ends of the fragments may be cut so as to interlock. In the early clean cases we do not hesitate to use internal fixation in the form of Lane plates. Sherman of Pittsburgh has obtained remarkable results by this method. He dakinizes the wound after plating. We prefer to treat it by the Orr method. We are not so preëminently qualified and equipped as Sherman for this method and it is only the exceptional case on which it should be used by the average

surgeon. In the oblique fractures, in which reduction cannot be maintained in plaster, we prefer transfixing the fragments above and below the fracture and well away from it with Steinmann pins, reducing the fracture in the Roger Anderson, or some other type of apparatus, and incorporating the pins in the plaster casing. We believe that the fixed, secure immobilization obtained by these methods is far superior to that obtained by traction suspension, and will materially reduce the incidence of infection, non-union, and delayed union.

The two greatly feared complications of compound fractures are sepsis and non-union. The treatment of sepsis does not differ from that in other wounds. The primary considerations are adequate dependent drainage, immobilization, maintenance of an adequate blood supply by posture and heat, adequate fluid and caloric intake, and the judicious use of sulfanilamide. The local treatment with antiseptics is entirely secondary and has little to do with the outcome. My personal preference is for irrigating the wound with azochloramide or packing it lightly with gauze saturated with this substance in triacetin. As soon as the infection permits, that is, becomes chronic or subacute, the Orr treatment is instituted.

There are two types of infection especially to be feared following compound fractures, gas gangrene and tetanus. The depth of the wound, the damage to muscle and fascia, and the contamination of most of the wounds with street or road dirt predispose to anaerobic infection. Except in unusual cases, all patients with compound fractures should receive a prophylactic dose of 1,500 units of antitetanus serum. The matter of using the anti-gas gangrene serum, or the combined anti-gas gangrene and antitetanus serum, is a matter of judgment. It is an unnecessary precaution in many cases and we use it only in thigh wounds and wounds in which there has been unusual destruction of tissue and in which satisfactory débridement and mechanical cleansing is not obtained.

The treatment of established tetanus and gas bacillus infection does not come within the scope of this paper, but we should mention some new advances in the treatment of gas gangrene. X-ray, as advocated by Faust and others, is of distinct benefit. Inhalation of pure oxygen is of benefit in two ways. The blood and tissues become supersaturated, thus increasing the partial oxygen pressure in the tissue, giving a distinct bactericidal effect on these anaerobic organisms. These organisms produce gas which distends the tissue and tends to cause necrosis by pressure and stoppage of the capillary blood flow. This gas is chiefly nitrogen; breathing pure oxygen greatly accelerates its absorption into the blood stream and elimination through the lungs. Fine and his associates in Boston showed that inhalation of pure oxygen will remove accumulated nitrogen from the body cavities or tissues in a comparatively short time. Air contains 79 per cent nitrogen; therefore, the blood, when the patient is breathing air, is about 80 per cent saturated with nitrogen when it leaves the lungs and can pick up very little more when it passes through the capillaries of the body. If, however, the patient is breathing pure oxygen, the nitrogen of the blood will be quickly thrown off in the lungs, more picked up as the unsaturated blood passes through the capillaries adjacent to the nitrogen containing cavity, carried to the lungs and exhaled. No ill effects have been noted from breathing 90 to 100 per cent oxygen for as long as two or three days. The percentage of oxygen is decreased as the patient improves. Of course these two new methods, and the use of sulfanilamide, are adjuncts in the treatment of gas gangrene, and wide incision and the use of serum should proceed concomitantly.

Non-union and delayed union are more common after compound than after simple fractures. The reasons for this are simple enough. (1) The damage to the soft parts

and periosteum is more extensive, thus interfering with the blood supply of the ends of the fragments. (2) Immobilization is usually less complete. (3) The blood clot between the ends of the bones which is the necessary first step in union is washed away or drained away. (4) Small fragments of bone may be lost at the time of the fracture, or may be removed by the surgeon during the débridement. These fragments are necessary as a source of calcium and as a bridgework for union. (5) Irrigation with Dakin's and other antiseptics has an inhibitory effect on callus formation.

To counteract these factors we must remove as little bone as possible. Only small pieces completely detached should be removed. No large fragment should be removed and any fragment even partially attached should be kept in place. When there are numerous small, loose fragments, or large detached fragments, which are soiled, it is much better to take them out, scrub and clean them thoroughly, and replace them than it is to remove them altogether. When the fracture is twelve hours old, or the fragments cannot be thoroughly cleaned, they should be boiled for twenty minutes and replaced. After boiling they still function as a source of calcium and as a bridgework for callus formation. Traction suspension which does not immobilize the fracture, loose, thickly padded casts or split casings, frequent changing of casings, too early removal, daily removal of splints for physiotherapy are, we believe, the causes of most cases of delayed union. Sepsis, if it occurs, is of course a frequent cause because of the destruction of tissue, interference with blood supply, sequestration of bone, and difficulty in maintaining immobilization. Immobilization should be as nearly absolute as possible and continued until bony union is obtained. We replace the first casing with a snug, unpadded one as recommended by Böhler. If these principles are carried out and the wound treated by the Orr method, or converted into a simple fracture by suture, we believe that the incidence of delayed or non-union will be as low as that in simple fractures.

SUMMARY AND CONCLUSIONS

Compound fractures constitute grave emergencies requiring as much surgical skill and judgment as any surgical problem. The treatment of shock, the treatment of the wound to prevent infection, and the treatment of the fracture itself should proceed simultaneously, and none should be emphasized to the neglect of the others. The general principles of our methods of treatment are described. The two paramount considerations are early, conservative, yet thorough, débridement and cleansing of the wound, and secure immobilization. Except in the early and clean case which can safely be converted into a closed fracture by suture, these ends are best attained by the Orr method. The incidence of delayed union and non-union is greater in compound than in simple fractures, but we believe this is preventable and can be corrected if the methods described are carried out. The use of x-ray and inhalation of pure oxygen are suggested in treatment of gas gangrene.
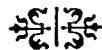
AMPUTATIONS AND PROSTHESIS

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FITTING physically handicapped persons into our social and economic structure has become one of the most

The fitting of artificial appliances and limbs is a difficult task. Many factors enter into the successful wearing of a limb.
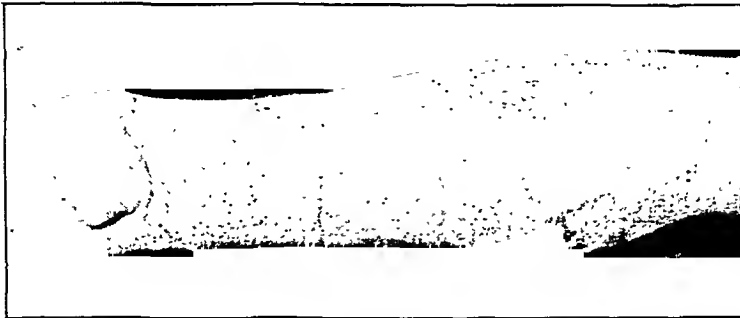
FIG. 1. Disarticulation at wrist. Note irregular contour at end of stump due to styloid prominence of radius. (From Kessler's "Accidental Injuries," Lea & Febiger.)

vital problems of our speed machine age. These disabled persons, the human waste of our foundries, textile mills and transportation systems, must be rehabilitated or become a permanent burden to the community. Each day traffic and industrial accidents result in permanent maiming or loss of limb. Disease and congenital deformity add their toll.

Among those who require this rehabilitation service the amputation case is one that requires careful consideration. On the basis of the Cleveland survey, Faries has estimated the number of persons with arm amputations in the United States to be about 33,000 and those who have suffered leg amputations about 118,000.

In most cases of amputation, the application of a prosthetic or special mechanical appliance is the first requisite to successful rehabilitation whether the person is returning to his former occupation or is engaged in a new one. It is not uncommon for persons who work even at heavy manual labor such as coal mining to return to the occupation in which they sustained an injury resulting in a leg amputation.

There is the site of amputation. Contrary to general surgical experience the length of the stump is not so important as one would expect, except when it is near the joint. For example, a disarticulation of the wrist (Fig. 1) is unsatisfactory because of the difficulty in fitting an artificial limb to the styloid prominence of the radius and ulna.

Circulation of the stump of the lower third of the forearm is very poor and patients frequently complain of pain and inability to wear their prosthesis. (Fig. 2.) The optimum site of amputation of the forearm is between the lower and middle third. An amputation of the forearm less than 2 inches below the elbow is useless because of the lack of leverage, the biceps being inserted just below that point. (Fig. 3.) A disarticulation through the elbow is unsatisfactory because of the difficulty in fitting a prosthesis. In the upper arm a long stump is necessary in order to get enough leverage to activate an artificial arm. A stump shorter than 3 inches below the axilla has no power to activate an arm. (Fig. 4.)

The use of a prosthesis in the upper extremity has been very unsatisfactory. In my own experience not more than 10 per

FIG. 2. Amputation through proximal row of carpal bones; extensive osteoporosis of lower end of radius and ulna, characteristic of circulatory and neurovascular disturbances associated with this type of amputation. (From Kessler's "Accidental Injuries," Lea & Febiger.)

cent of the persons with upper arm amputations wear their prosthesis. Successful wearing of a prosthesis depends upon the character of the stump, the attitude of the individual and the nature of the prosthesis. A stump that is tight, that ulcerates easily, that is painful because of poor circulation or presents a neurofibroma, will prevent the patient from wearing the best type of limb. On the other hand a good stump and a good limb will be of no advantage to one who refuses to coöperate. One of the reasons for this breakdown of morale on the part of many of these amputees is their disappointment at not being able to operate the

artificial arm as well as the salesman who is expert from years of practice.

In the upper extremity a careful analysis

FIG. 3. Amputation just below elbow. Unsatisfactory for prosthesis. (From Kessler's "Accidental Injuries," Lea & Febiger.)

FIG. 4. Disarticulation at shoulder; unsatisfactory for prosthesis because of absence of leverage. (From Kessler's "Accidental Injuries," Lea & Febiger.)

should be made of the personality of the individual and of his occupational needs, as well as of the character of the stump, before deciding on a plan of procedure. There are several objectives open, depending upon

FIG. 5. Amputation of thumb, index and middle fingers, leaving satisfactory stump for prosthesis.
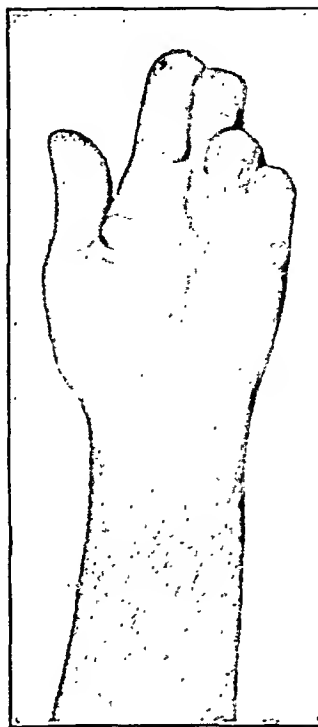
FIG. 6. A, partial amputations; unsatisfactory for prosthesis but retention of index finger stump adequate for prehensile functions. B, fingers closed, showing grasping power. (From Kessler's "Accidental Injuries," Lea & Febiger.)

FIG. 7. Partial amputations of thumb and index finger and contraction of little finger; unsatisfactory for prosthesis but better for surgical restoration of thumb. (From Kessler's "Accidental Injuries," Lea & Febiger.)

the site of amputation. In an amputation of the fingers below the proximal interphalangeal joint, an amputation of the

very difficult to fit a prosthetic appliance in partial finger amputations where the stumps project beyond the metacarpo-
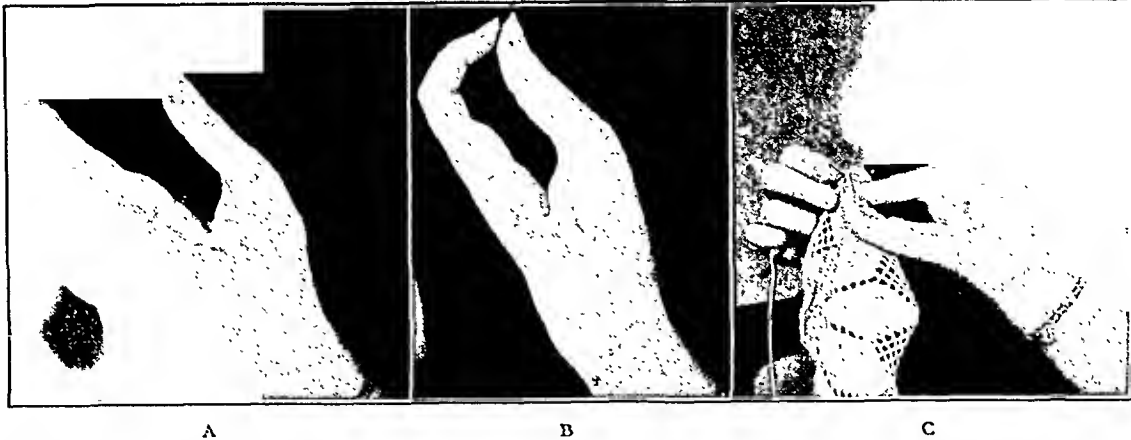
Fig. 8. A, amputation of index, middle and ring fingers. B, opposition between thumb and little finger. C, at work.

stump below the metacarpophalangeal joint is encouraged in order to give a better

phalangeal joints. (Figs. 6–13.) Nevertheless a prosthetic appliance can be fitted to

Fig. 9. Amputation of all fingers and partial amputation of metacarpals. Satisfactory for prosthesis. (From Kessler's "Accidental Injuries," Lea & Febiger.)
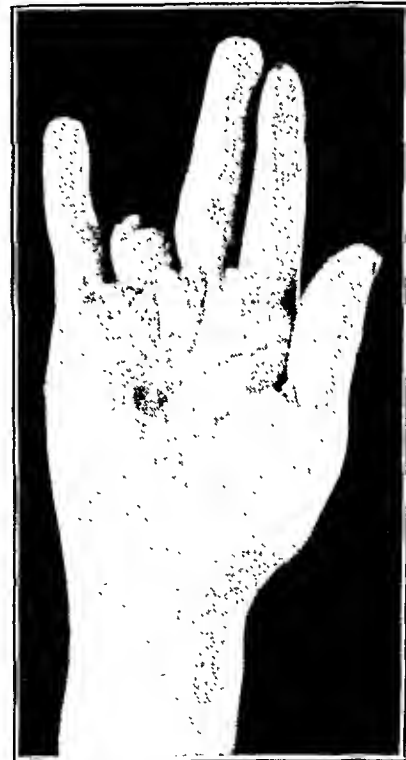
Fig. 10. Unsatisfactory and unsightly stump of ring finger amputation. (From Kessler's "Accidental Injuries," Lea & Febiger.)

cosmetic hand and also to facilitate the wearing of a special prosthesis where more than one finger is involved. (Fig. 5.) It is

these hands, but should only be applied in the case of multiple finger amputations. (Fig. 14.)

In the case of forearm amputations the amputee has several alternatives:
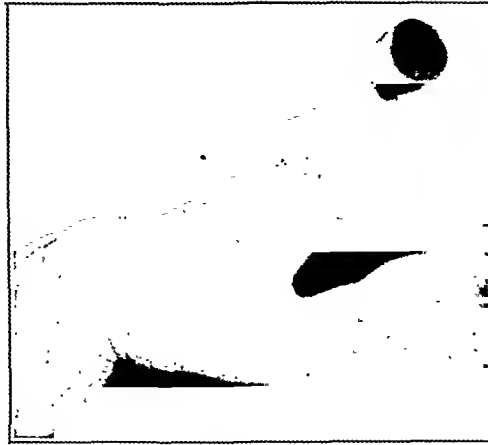
FIG. 11. Extensive resection of middle, ring and little fingers with their metacarpals. Prehensile function retained between thumb and index finger. (From Kessler's "Accidental Injuries," Lea & Febiger.)
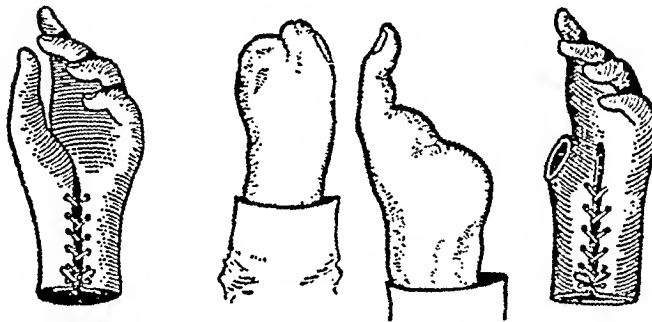
FIG. 12. Types of prosthesis for partial finger and hand amputations.

FIG. 13. Amputation of all fingers and thumb through mid-hand. (From Kessler's "Accidental Injuries," Lea & Febiger.)

The patient may be trained to use his stump in the daily pursuits of life sometimes with and sometimes without the use

Fig. 14. Same case, with prosthesis. (From Kessler's "Accidental Injuries," Lea & Febiger.)

of a circular strap about the end of the stump in which may be held any implement from a work tool to a tooth brush. This is particularly true in double forearm amputations. One of the most prominent amputees of this type was Lew Young who was able to take care of himself completely without the aid of any prosthetic appli-

ance. He was, of course, an unusual personality.

The Krukenberg amputation is adaptable to forearm stumps of almost any length. (Figs. 15, 16 and 17.) In this procedure the forearm is split into two "fingers" and grasp and prehensile function is carried on between the two pinchers thus formed. This procedure has not been very popular in America although it is used in Germany quite successfully.

Fig. 15.　　　　　Fig. 16.　　　　　Fig. 17.

Fig. 15. Krukenberg amputation of right forearm; application to carpentry.
Fig. 16. Use of file with Krukenberg amputation.
Fig. 17. Training as bookbinder, with Krukenberg amputation.

FIG. 18. Use of mechanical arm in planing and carpentry.
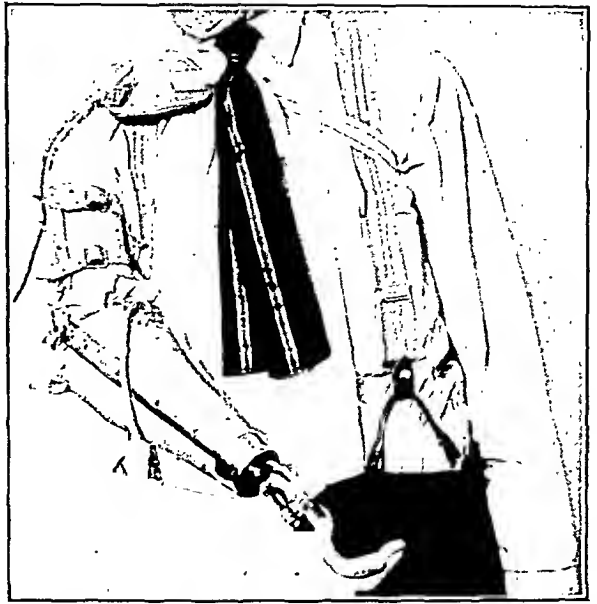
FIG. 19. Usual type of mechanical arm activated by cord attached to opposite shoulder. (From Kessler's "Accidental Injuries," Lea & Febiger.)
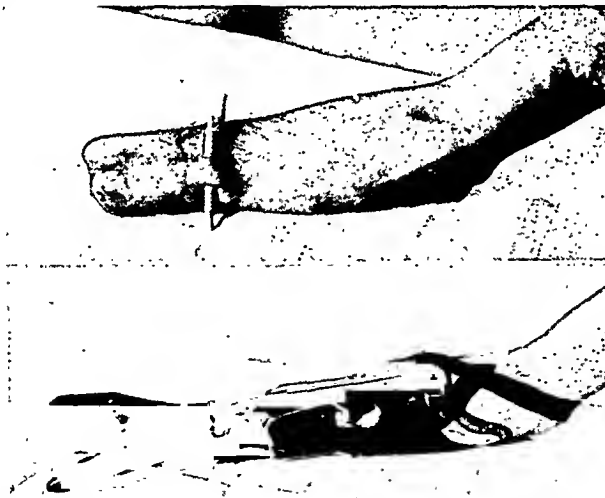
FIG. 20. A, volar and dorsal motors in forearm. B, with prosthesis. (From Kessler, in *South. Surg.*, 7: 285, 1938.)

A   B   C

FIG. 21. A, left forearm stump, showing pegs. B, adjusting left prosthesis with right. C, smoking a cigarette. (From Kessler, in *South. Surg.*, 7: 285, 1938.)

The common type of prosthetic appliance used is a cosmetic arm without any prehensile function in the hand, which may

Fig. 22. Double motor in upper third of forearm.

be equipped with a rubber hand which can be placed in various positions by the sound hand. (Fig. 14.)

The most common type of mechanical arm is one in which the hand mechanism is activated by a cord attached to the oppo-
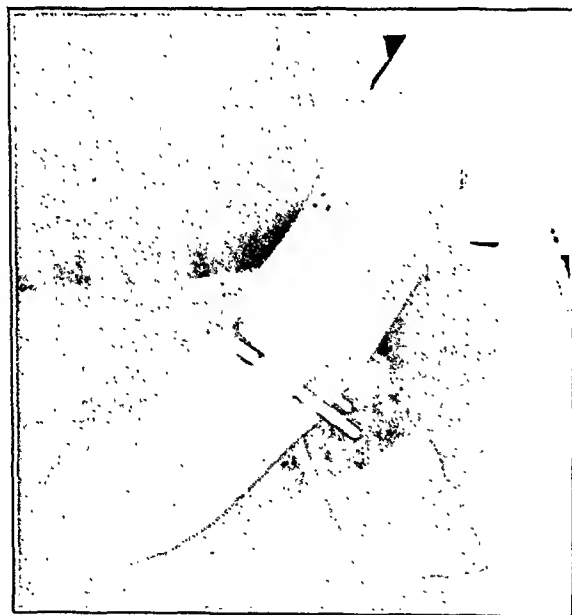
Fig. 23. Congenital amputation with biceps and triceps motors.

site shoulder. Adduction movement of both extremities produces a pull of this cord which opens the hand mechanism, while a spring produces closure of the hand by releasing the shoulder movement. (Figs. 18 and 19.) There is little difference in the

general construction of these appliances, as the principles are essentially the same in practically all types of mechanical arms.

Fig. 24. Same case as Figure 23, with prosthesis.

Where an individual has to do heavy work, the arm may be of heavier construction, permitting him to carry on even heavy industrial activity. Some of these appliances are fitted with removable hooks such as a Bowler or Dorrance hook. (Fig. 19.) These hooks are also activated by the indirect pull of the shoulder applied to a cord or string attached to the hook.

The problems which face us in the fitting of an appliance to the arm stump are extremely difficult. Complete restoration of function by any mechanical means of an amputated hand or arm is quite beyond
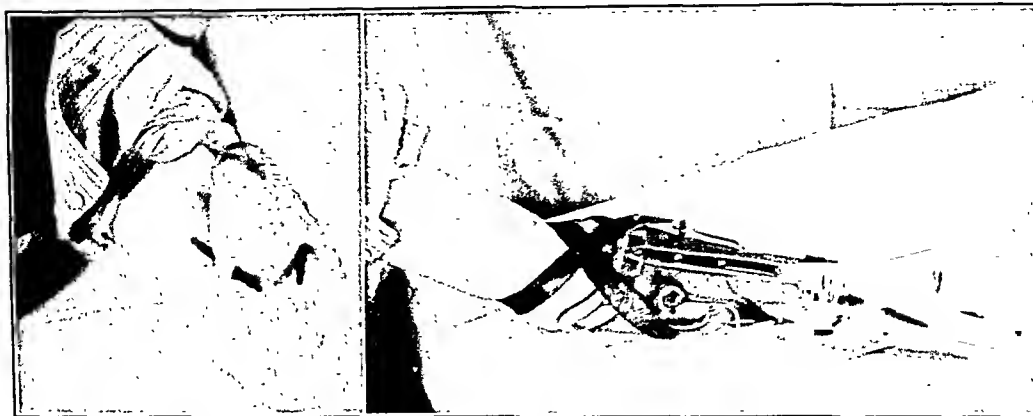
FIG. 25. A, double motors through flexors and extensors of lower arm. B, with prosthesis.

FIG. 26. A, high amputation of upper arm. Use of deltoid and short head of biceps for volar motors. (From Kessler, in *Soutb. Surg.*, 7: 285, 1938). B, triceps canalized for dorsal motor.
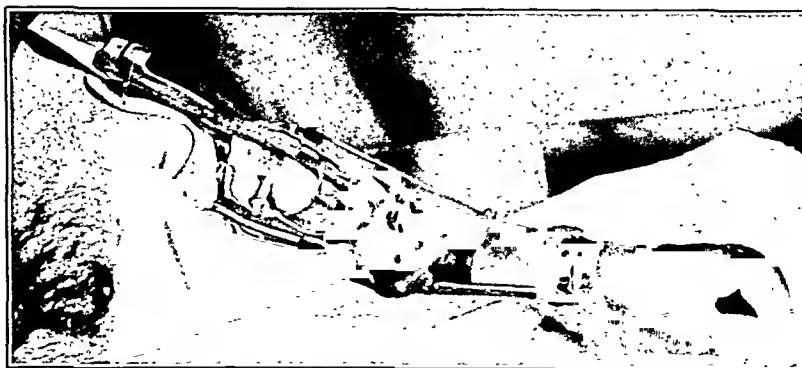
FIG. 27. Prosthesis for upper arm amputation with triceps and biceps motors.

human invention. Although some of the simpler prehensile actions of the hand can be imitated by jointed fingers, one should

muscles and attached to levers operating the artificial hand mechanism, the physiologic action of the stump muscles is re-

FIG. 28. Forearm and upper arm amputation. Fitted with cineplastic prosthesis. Reemployed in hair felt factory repairing needle board. (From Kessler, in *South. Surg.,* 7: 285, 1938.)

not raise false hopes in the minds of the armless.

Only a small proportion of those supplied with artificial arms wear them and a still smaller proportion actually use them. My personal survey of 1,500 arm amputations has covered 230 of these over a period of six years. At the end of this time only 12 per cent of this group were wearing their artificial arms and 6 per cent used them for work and in the routine pursuits of life.

Because of the unsatisfactory experience with the ordinary mechanical arm, interest has been revived in the cineplastic arm in which the control of the artificial hand mechanism can be achieved by natural muscular action. This method was suggested by Vanghetti, while Sauerbruch has been its most ardent exponent.

In the cineplastic amputation the remaining muscles in the amputation stump are utilized to activate the prosthesis. By means of pegs passed through canals in the

stored. (Figs. 21, 22 and 23.) The biceps and triceps muscles in the upper arm (Fig. 24) and the flexors and extensors of

FIG. 29. Double upper arm amputation. Later fitted with cineplastic arms. Left arm satisfactory and right unsatisfactory.

the lower arm (Fig. 25) control the grasp and release of the fingers of the artificial hand. Thus the stump retains its real task

of guiding the hand without other problems, such as leverage, being added, as they are in the mechanical hand. Though the

FIG. 30. Good stump of lower leg for prosthesis. (From Kessler's "Accidental Injuries," Lea & Febiger.)

fingers of the artificial hand have no feeling, natural control is nevertheless exerted by the muscles in the act of grasping,

FIG. 31. Willow leg for above-the-knee amputation. Fitted with shoulder harness. (From Kessler's "Accidental Injuries," Lea & Febiger.)

thereby permitting a close approximation to natural hand function. (Figs. 26, 27 and 28.)

In double arm amputations the cineplastic operation is of the greatest benefit. Again, however, a great deal depends upon the personality of the individual and the site of amputation. Where both arms are amputated above the elbow, the possibilities for rehabilitation are very poor. (Fig. 29.) Where one is amputated below the elbow and one above the elbow, the chances are better. Where both arms are amputated below the elbow, the possibilities for adjustment are still greater.

LOWER EXTREMITY

Although appliances are of limited value in the upper extremity, in the lower extremity they are vital. The prime consideration in the lower extremity is the substitution of the weight-bearing power of the normal leg by an artificial leg. Weight-bearing, then, is the main purpose of the prosthesis.

The site of amputation in the lower extremity is also important. In the forepart of the foot the heads of the metatarsals should be saved if possible. If the injury is beyond the heads of the metatarsals it is better to do a Syme's amputation than to try to save tissue. In the lower leg, the optimum site is the middle third, that is, about 8 inches from the tibial tubercle.

(Fig. 30.) The shortest leg stump that is usable is one that is ½ inch below the insertion of the biceps tendon.

Fig. 32. Metal leg for Chopart amputation.

In all lower leg amputations the fibula should be cut 1 inch shorter than the tibia. If the stump is less than 4 inches the fibula should be removed entirely. At or above the knee the Stokes-Gritti amputation or one at the lower third is desirable. A disarticulation at the hip is not desirable although a prosthesis can be fitted.

In the modern manufacture of prostheses for the lower extremity the use of the end weight-bearing stump has generally been discarded. Weight is usually borne along the lateral sides of the stump into perfectly
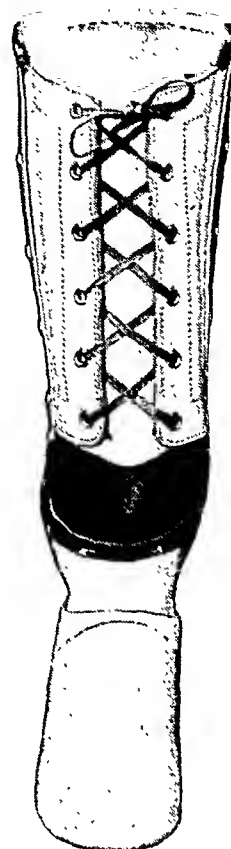
Fig. 33. Metal leg for Syme amputation.

fitted encasements or, in upper leg amputations, weight is borne on the tuberosity of the ischium. The limbs may be fashioned from willow hollowed out to fit the stump perfectly (Fig. 31) or they may be made of aluminum alloys or similar metal. (Figs. 32, 33, 34, and 35.) These limbs are light and should not weigh more than 6 or 7 pounds. In an average individual of 160 pounds in weight each leg weighs approximately 26 pounds.

A man who wears an artificial leg is the least disabled of all cripples although in some cases he may be disqualified for standing work. Cases of double leg amputation, however, offer a serious problem. If one of the stumps is below the knee then it is not uncommon for the individual to be able to get about with the aid of a pair of full limbs. In these cases we usually recommend short legs, that is, legs without any knee joints and much shorter than the

regular length so that there is less mass and inertia to overcome in lifting up the limb and moving it. In heavy individuals even

FIG. 34. Metal leg for below-the-knee amputation.

this method is unsatisfactory, while light individuals are sometimes able to wear full length limbs.

SUMMARY

To recapitulate, attention should be given to furnishing the injured man with a suitable prosthetic appliance should he

need one. Unfortunately in the past the man who had lost a limb was confused by the claims of rival concerns, each insisting
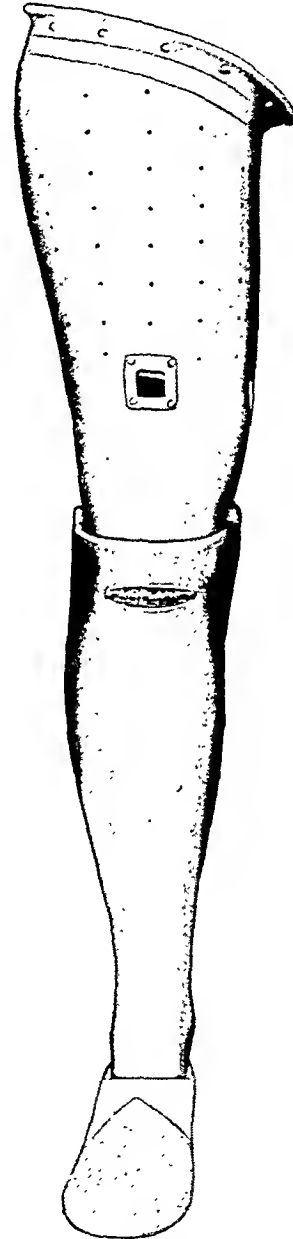
FIG. 35. Metal leg for above-the-knee amputation.

that his was the best manufactured arm or leg. There are many good makes of limbs which when properly fitted give satisfactory service. Someone, however, who is competent to say whether a limb is properly made and fitted should stand between the manufacturer and the amputee if the latter's interests are to be safeguarded.

AMPUTATIONS IN OBLITERATIVE VASCULAR DISEASE*

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Assistant Attending Surgeon, New York Post-Graduate Medical School and Hospital

NEW YORK CITY

INFECTIONS, trauma and diseases requiring surgical intervention in patients with an underlying vascular disease require a modified form of therapy, and unless the pathologic basis for this variation is recognized and treated accordingly, serious complications may develop. In patients with vascular disease, conservatism is the keynote and this non-operative régime, in the absence of spreading infection, frequently forestalls or minimizes the necessity for the operation. In vascular disease there is a reduction in the available blood supply with restricted collateral vessels and lack of resistance to operative trauma and infection. An incision through such tissue results in the interruption of these small vessels and slough and death of surrounding tissue. An amputation of a toe with a plastic closure of the stump is followed by the breaking down of the wound and extension of the gangrene to the proximal end.

The vascular problem resolves itself into the infectious and the obliterative aspects. In most instances both types are present to some degree. The program is to restrict the infection until conservative measures to stimulate and form collateral supply are successful. In no other condition is it so important to have combined medical and surgical care as in the patient with vascular disease. In many institutions, when a patient is transferred from the medical to the surgical service, the interest of the internest lags. In vascular problems this would be most serious. The fine point at which medical must yield to more radical methods requires careful study. Such a conception of the necessity for a group study and treatment has led to the combined Vascular Clinic at the New York Post-Graduate Hospital, in which both medical and surgical problems are discussed and treated jointly.

To review briefly the types of vascular patient requiring surgical therapy, an outline is presented.

I. Obliterative vascular diseases:
  (a) Thrombo-angiitis obliterans (Buerger's type), in younger individuals, tobacco smokers, frequently Jewish. Progressive occlusion.
    1. Conservative therapy—local amputations only when demarcation is complete.
    2. Radical amputation rarely necessary if control and conservative therapy has been complete. Occasionally consider sympathectomy.
  (b) Arteriosclerosis with endarteritis obliterans, in elderly people of all races. X-ray evidence.
    1. Conservative therapy—local amputations only when demarcation is complete.
    2. Radical amputation necessary only when infection becomes uncontrolled and gangrene spreads. Amputation, when necessary, usually must be high.
  (c) Diabetes mellitus with endarteritis obliterans.
    1. Conservative therapy may be tried briefly but if evidence of spreading infection is present, more radical procedures are necessary.
    2. Radical amputation earlier than in any other condition. Usually requires high amputation.
  (d) Periarteritis nodosum—rare.

II. Acute arterial occlusion:
  (a) Embolism.
    1. Conservative therapy, if seen after ten hours of onset. Efforts to stimulate collaterals by vasodilators, oscillating bed, controlled heat, suction pressure boot, etc.
    2. If seen in first ten hours, operative removal of embolus and plastic closure.
    3. Amputation, if gangrene continues and collaterals fail.
  (b) Arterial thrombosis.
    1. Conservative therapy in effort to stimulate collateral circulation as described before.
    2. Radical amputation, only if collaterals fail.
III. Aneurysm: Amputation required, if operative obliteration or collateral development fails.
IV. Vasospastic vascular disease:
  (a) Raynaud's syndrome.
  (b) Traumatic spastic diseases.
  (c) Frost-bite, etc.
  (d) Scleredema.
  Rarely requires amputation, except in frost-bite, unless neglected. Sympathectomy valuable.

While our province is not to discuss the medical treatment of obliterative vascular disease, a brief outline may be mentioned. External heat is maintained by a light cage or a thermostatically controlled vasculator. Postural vascular exercises are continuous by means of the oscillating bed or postural change exercises. Vasodilatation is stimulated by such antispasmodics as spasmalgin, papaverine, alcohol and mecholyl by iontophoresis. The associated fungus infection is relieved by weekly soaks of 1:5,000 potassium permanganate solution. Locally, all irritating antiseptics and ointments are eliminated. Warm sterile saline soaks are used twice a day where there is infection, and pocketing of pus is prevented by daily dressing. The suction pressure boot has its limited place in the treatment, espe-cially in complete arterial blockage. In the thrombo-angiitis obliterans group, intravenous typhoid vaccine in increasing doses (but not to the chill stage) is most helpful. The adrenalin neutralizing tissue extracts are efficacious especially in the arteriosclerotic type. Diabetes requires its special care.

Local Amputations (Toes). Patients with vascular disease are allowed thoroughly to demarcate the site of amputation and, where possible, to self amputate themselves. During this period of demarcation, epithelization occurs at the line of separation, and an incision through this part destroys small capillary buds and tissue healing efforts and causes further tissue death. Where the gangrenous toe is acting as a foreign body or as a drainage block or focus of infection, it is well to remove it surgically, with a minimum of trauma. The toe is best disarticulated and the tendons are left long to act as drains. This operation should be done under a light general anesthesia only. Local infiltration of the tissues in vascular disease may cause tissue death, either from pressure necrosis of the fluid on small arterioles, or from the action of adrenalin frequently included in the novocain. Figure 1 shows the necrosis resulting from anesthesia block for excision of an ingrown toe-nail in a patient in whom thrombo-angiitis obliterans previously was not diagnosed. With conservative therapy, demarcation occurred and local amputation with tendon drainage was effective. Figure 2 shows the foot healed and the amputation site closing by granulation, after the necrotic tendons had sloughed.

No foreign drain material can serve so well as the sloughing tendon end. In addition, if the tendon is cut, it retracts up the sheath, setting up a new focus of necrosis. No suturing is required and the wound is best treated without wet dressings. Where accumulations of discharge require removal, hot sterile soaks for an hour twice a day, immediately followed by a dry or open dressing, are most adequate. The

surgical incision with plastic closure in the patient with vascular disease frequently will not only fail to heal, but will be fol-

tion overshadows the obliterative side and procrastination can be practiced only for a limited time. If, with diabetic control,

FIG. 1. Gangrene of great toe and threatened gangrene of limb after novocaine block at base of toe for excision of ingrown toe-nail. This patient had previously undiagnosed thrombo-angiitis obliterans.

FIG. 2. Same foot as in Figure 1 after demarcation and amputation of toe and conservative therapy.

FIG. 3. Embolic gangrene. Embolus of cardiac origin to division of anterior and posterior tibial arteries. Gangrene to upper tibial area. Shaded area above gangrene demarcation indicates estimated area of incompetent collateral circulation. Operation findings—poor viability to point 6 inches above shaded area.

lowed by an extending gangrene and possibly limb loss.

While conservative surgery will be effective in most obliterative vascular diseases, in the *diabetic patient* the tendency to infec-

the previously outlined general and local therapy does not bring early improvement, amputation must be considered. In these individuals the amputation site should be high (thigh).

Major Amputations. The decision as to site of amputation is made after palpation of the vessels, oscillometer readings, x-ray
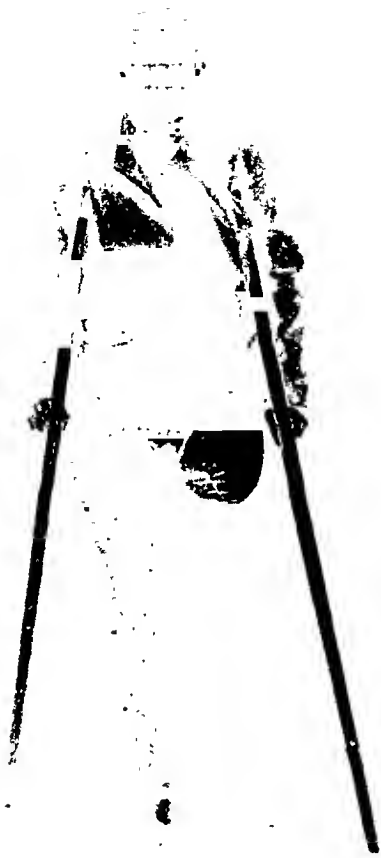
FIG. 4. Embolic gangrene after high amputation. Patient (age 33) able to walk well with artificial limb despite short stump.

findings and in some instances, with Roentgen view after intra-arterial thorotrast injections. The majority of the individuals are in such precarious physical condition that careful preoperative preparations must be made.

Preoperative Care. The general preparation, such as cathartics, enemas, glucose and fluid balance requirements necessary for any serious operation are most important in these patients. If there is an anemia, a blood transfusion should be given preoperatively and preparations completed for a second transfusion after operation. Hyperglycemia should be adequately con-

trolled and prior to the operation, an ample supply of glucose and saline, covered with sufficient insulin, administered to permit the patient to run a small percentage of sugar in the urine. Care to prevent exposure in the operating room with resulting pneumonia, is important and the use of a suit of old-fashioned long underwear has proved most satisfactory in this respect. Because anaerogenous organisms inhabit the colons of these older people, gas gangrene may be a problem. The adoption of routine use of prophylactic gas gangrene serum the day before operation has eliminated this complication.

The local preparation of the leg to be amputated is most important and the routine is described.

1. The leg, thigh, groin, rectal areas, scrotal or labial areas are shaved with great care to prevent any cuts or scratches.

2. The leg, groin, perineum and rectal areas are thoroughly cleansed with green soap the day before operation, followed by alcohol preparation and the covering of the limb with a sterile sheet.

3. This preparation is repeated three hours before operation time.

4. This is again repeated in the operating room by the assistants just before operation.

5. A soapsuds enema is given the night before and the morning of the operation.

6. In the female a cleansing vaginal douche ($\frac{1}{2}$ per cent lysol) is given the night before and the morning of operation.

7. The prophylactic gas gangrene serum is given as ordered, (after sensitization tests).

Operation. Anesthesia. We have found that a light gas is our safest anesthesia for this group of patients and, unless otherwise contraindicated, it is used routinely. Cyclopropane has been more satisfactory than nitrous oxide because more oxygen may be used. Infiltration anesthesia, while ideal from the patient's general condition, increases the risk of surface infiltration of contaminating anaerogenous organisms and may cause necrosis. Spinal, with its

peripheral dilatation, may aggravate the shock already present. Operation time is reduced by completing the preparations tourniquet. The femoral artery at the fossa ovale is marked, so that digital pressure could prevent any serious hemorrhage.

NEW YORK POST-GRADUATE MEDICAL SCHOOL AND HOSPITAL
ANAESTHESIA STUDY RECORD

Anes. No. . . . . Hosp. No. . . . . .
Name . . J. B. . . . . Pr. S. P. S. S. Age 84 Ward 257   Date 1 2 3 4 5 6 7
Op. Proposed Amputation of Left Leg . . . . Time 4:00   PS 1 2 3 4 5 6 7
Prelim. Med. Atrophine grs. 1/150 . . . . Time 3:30   Surgeon Pratt
Admin. H

Too Depress.—Worn Off—
Appreh.—Not Depress.—
Others—
Patient moribund

INDUCTION
Exc.
Larsp.
N-E.
Asphyxia

MAINTENANCE
Pt. condition
satisfactory
until sciatic
nerve was
severed.
B.P — o
Pulse — o
Resp. — no change
After Trendelen
berg position
and infusion —
B.P. and Pulse
again obtainable

RECOVERY
Reflex in O. R. Yes—No—
CO₂—Retch.—Vomit.—
Excit: M.——S.——

REMARKS
Sciatic Nerve sectioned
Infusion

Code   ●Pulse   O Resp.   vv B.P.   x Anes.   O Opr.

Airway to Ward {Yes}

Agents—Primary
Agents—Sec. C₃H₆   Technic   Abs.   Reason choice

Operation . Amputation of Left upper thigh.
Surgeons .. Drs. Pratt — Lyall — Clapp
Anesthetists .. Dr. Zacher   S—U

Fig. 5. Anesthesia chart showing shock occurring with section of sciatic nerve. This may be prevented by novocaine infiltration before division of the nerve.

before inducing the anesthesia. Carbon-dioxide-oxygen rebreathing, postoperatively, reduces pulmonary complications.

Because of the disease already present in the blood vessels, we feel it is better to amputate the limb without the use of a

The circular incision is carried directly to the femur with division of all muscles on tension. The femoral vessels are isolated at once, opened to determine the adequacy of the blood flow and ligated with a transfixion suture. After arterial thrombosis or

embolism, there may be tissue death above the area suspected and at amputation time this may be determined.

Figure 3 shows a patient with arterial embolism (from cardiac site) to the bifurcation into the posterior tibial and the dorsalis pedis arteries with gangrene to the lower leg. The deeper shading above the gangrene indicates the area to which we attributed poor collateral supply. At amputation time it was necessary to go 6 inches higher than the shading to find viable tissue. Figure 4 shows the patient after the high amputation required for this embolism.

The sciatic nerve is injected with 2 per cent novocaine anesthesia before it is sectioned, to reduce the accompanying shock. The anesthetizing of the sciatic nerve is highly important as there is a definite shock accompanying the division of a large nerve. This novocaine injection should be done early so that the anesthetic effect is complete before sectioning. The anesthesia record in Figure 5 shows the degree of shock present in one individual when the sciatic nerve was cut. In some instances this may be sufficient to cause death.

The nerve is ligated, injected in "cartwheel" fashion with absolute alcohol to prevent neuromata and permitted to retract. The muscles are retracted and the femur is cut with a hand saw. The roughened bone edges are filed with a wood rasp to remove possible osteophytes. All bleeding is controlled and the wound is closed by interrupted sutures of number 32 and 36 alloy steel wire. No effort is made to create a muscle, fascia or skin flap. Muscle flaps hold serum, make the stump thick and unwieldy and, with present artificial limbs, are unnecessary. Unless there is some specific indication, no drain is inserted.

The wound is securely sealed with compound tincture of benzoin, a liquid adhesive dressing, and adhesive strips, with a final covering of white shellac to insure water tightness. We believe that the stump infections occur from contamination postoperatively and we prevent these infections in every way. Many of the patients are incontinent and, previously, we have seen wounds contaminated before the patient left the operating room. Attention to this detail, as much as any other part of the routine, has decreased the morbidity to 8 per cent (one in last twelve patients).

Because of the tendency to muscle and skin retraction, a modified Buck's type of extension is applied by winding adhesive strips down the side of the stump and then over the end of a board splint applied to the side of the stump. A blood transfusion is given after the operation, not only to reduce the shock and blood loss, but also because a blood transfusion is an excellent means of stimulating collateral circulation.

Postoperatively, the medial routine followed before the operation is begun at once. The patient is returned to the oscillating bed, nourishment is maintained and the thermostatically controlled heat is reapplied. The injections of adrenalin neutralizing pancreatic extracts are continued if indicated, and the patient is permitted out of bed early to lessen the chances of pulmonary complications. Diabetic management continues if the patient requires it. If there is no systemic reaction, the wound is not disturbed for seven days. Sutures are removed late and the modified Buck's extension is maintained for ten to fourteen days.

On the Vascular Service of the New York Post-Graduate Hospital in the last five years, there have been thirty-two patients with thrombo-angiitis obliterans who have developed gangrene of the foot. That the outlined conservative therapy is efficacious is attested by the fact that there has been only one (3.1 per cent) major amputation for this condition. When it is considered that amputation was the usual end result in thrombo-angiitis obliterans until recently, it will be seen that this is a remarkable decrease.

During the same length of time, eighty-four patients with endarteritis obliterans

(arteriosclerosis with some diabetics) have had gangrene of the foot. In this group twenty-four, or 28.5 per cent, have had major amputations. In spite of the frequent self neglect and the age of these patients, we anticipate a further decrease in the amputation rate in the next five years.

While the mortality rate will always remain fairly high, since there has been close adherence to the described technique there has been but one death in twelve major amputations and that one resulted from gas gangrene infection in an elderly individual to whom it was considered too dangerous to give the prophylactic serum preoperatively. Since that time the serum has been used in every instance.

SUMMARY

The underlying arterial pathology in patients with vascular disease makes it necessary to vary treatment of infections and injuries.

Local lesions requiring amputation must be allowed to demarcate and plastic closures usually fail.

Major amputations can be made relatively safe by the adoption of a standard medical and surgical routine with careful preoperative and postoperative care.

An operative technique for vascular thigh operations is outlined.

The combined attention of the medical and surgical attendant with the basic vascular problem in mind is advocated.
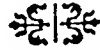
SURGICAL FUSION OF UNSTABLE JOINTS DUE TO NEUROPATHIC DISTURBANCE

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CHARCOT'S disease of joints, due either to tabes dorsalis or syringomyelia, may occur in any joint, but port on the most bizarre looking joints. (Fig. 1.)

The problem of stabilization is present

FIG. 1. Roentgenograms of the right knee and right foot of a negro woman of 55 years with tabes dorsalis and Charcot's disease. The disintegration of both right knee and the right first metatarsophalangeal joints is far advanced, but she is walking without marked difficulty using only a cane. She was last seen on November 1, 1938, when these roentgenograms were made. The destructive changes are so far advanced that any attempt at fusion is out of the question.

the weight-bearing joints are far more frequently involved. The knee, hip, spine and tarsal joints are the usual sites of this disease. I have seen one instance in which the shoulder joint was invaded.

These neuropathic joints are usually enormously swollen, deformed, and quite painless. The problem is one of instability which increases with time and use. Braces may be used but are often discarded by the patient because there is no pain. As long as there is sufficient stability to allow any weight bearing, the patient is apt to hobble around with unsightly deformity, producing further disintegration of the joint by the repeated small traumata incident to walking. At times they walk without sup-

only in the weight-bearing joints, and of these the knee has received most attention. This is probably due to the fact that Charcot's disease is most frequently encountered in the knee and that this joint, under ordinary circumstances, lends itself most satisfactorily to surgical stabilization by fusion. Cleveland and Smith,[1] in 1931, reported four cases of Charcot's disease of the knee in which fusion had been performed with success in three. Cleveland,[2] in 1935, reported another case of Charcot's disease of the knee in which fusion was successfully accomplished after two attempts. The ankle and tarsal joints may be attempted, but the hip joint in this disease is so very unstable that fusion from a

technical standpoint should have but little or no chance of success. (Fig. 2.)

A very large percentage of the patients with Charcot's disease are totally unfit for surgery. Only an occasional individual can be considered as having sufficient chance of success to warrant the time and effort required to secure a stable joint by surgery.

During the past few years, I have encountered only two additional cases of Charcot's disease which were considered suitable for surgical intervention.

CASE 1. H. G., a 24 year old white male, was first admitted to St. Luke's Hospital March 10, 1933 with a diagnosis of syringomyelia. The first indication was an infected callus on the left foot under the fifth metatarsal head in November 1929. This was considered a trophic ulcer. The patient went to many hospitals, developing an osteomyelitis of the metatarsal bone and phalanges of the left fifth toe. He was seen at Johns Hopkins and at Montreal General Hospital, where the diagnosis of syringomyelia was confirmed.

On March 3, 1932, a left lumbar sympathetic ramisectomy was done with improvement in circulation to the left leg and foot. The joints of the left tarsus and foot, however, underwent disintegration. At first admission to St. Luke's Hospital, an arthrodesis of the left subtalar joint was performed and a circular plaster splint was applied. The destructive changes progressed throughout the foot, and amputation of the left leg at the junction of the upper and middle third was done on October 3, 1933. An artificial leg was fitted and worn with comfort.

On April 13, 1934, the patient sustained a fracture of the right tibia and fibula with minimal trauma; the leg almost gave way spontaneously. Roentgenograms of the fracture showed degenerative changes taking place in the right ankle. Rather rapid disintegration of the right ankle joint ensued. Owing to his previous left sympathetic ramisectomy, he failed to show a completely typical picture of syringomyelia.

On September 20, 1934, his fourth admission to the hospital, the right ankle was enormously thickened, painless, with marked crepitation on motion. The roentgenograms showed changes typical of a neuropathic joint. On September 21, 1934, a right lumbar sympathetic ramisec-

tomy and fusion of the right ankle joint was done.

The ankle joint contained 10 to 15 c.c. of

FIG. 2. Roentgenogram of a right hip with spontaneous fracture and disintegration of the head and neck of the femur in a white man 62 years of age. He had all the classic signs of tabes dorsalis, positive Rhomberg sign, absent knee and ankle jerks. This patient walks with a brace. He is shown as an illustration of the instability of the hip joint in Charcot's disease which practically precludes any attempt at surgical fusion.

straw-colored fluid. The synovial membrane was hypertrophied. A number of loose fragments, similar to joint mice, were removed. The tibial and talar articular surfaces were greatly hypertrophied.

The ankle fusion was done by a sliding tibial graft into the talus after the articular cartilage had been removed. A plaster of Paris boot from toes to knee was applied.

Pathologic Report. Microscopic examination: "Sections show many small dilated blood vessels beneath the synovia which is repre-

sented by a broken, flat layer of epithelial cells. Evidence of fibrous changes and chronic inflammation is present. Sections of the bone

FIG. 3. Case I. A, preoperative roentgenograms, September 10, 1934, of ankle joint in anteroposterior and lateral views, showing definite fragmentation and capsular distention. B, postoperative roentgenograms, April, 1, 1937, showing solid bony fusion of the ankle joint, anteroposterior and lateral views, with some sclerosis of the subtalar joint.

FIG. 4. Case II. Preoperative roentgenograms of the left knee. The joint is severely disorganized with a great deal of detritus. No marked subluxation. A typical roentgenographic picture of Charcot's disease.

show considerable productive inflammatory change and callus formation without evidence of any specific process. Diagnosis: Chronic productive osteitis and synovitis of right ankle." Signed, L. C. Knox, pathologist.

On May 13, 1935, a little under eight months after operation, the ankle fusion was solid. The latest follow-up examination, November 1, 1938, revealed the right ankle solidly fused and stable. The patient walks very well indeed on the right foot and left artificial leg. (Fig. 3.)

CASE II.   K. L., a 39 year old white male, was admitted to St. Luke's Hospital on December 17, 1936, complaining of instability of the left knee of four years' duration. The

joint was swollen with considerable effusion, deformed, painless, and unstable with motion in all directions. The pupils did not react to light. Knee jerks and ankle jerks were absent. The heart showed a blowing systolic murmur at the apex and a double murmur at the aortic area. The blood Wassermann was indefinite, but the spinal fluid was four plus with both antigens. Roentgenograms of the left knee showed fragmentation with marked condensation of the bones and swelling of surrounding soft tissue. A diagnosis of Charcot's disease was made, and a fusion of the joint was attempted December 28, 1936.

The knee joint was found markedly swollen and generally disintegrated. The bone ends were eburnated and soft tissues were thickened. The tibia and femur were flattened with a

chisel so that the bone surfaces were brought into firm apposition. The patella was denuded of its cartilage and was fitted into a groove

arthritis of the knee joint, Charcot type." Signed, L. C. Knox, pathologist.

Postoperative Course. The patient ran a

Fig. 5. Case 11. Postoperative roentgenograms of the left knee, twenty-two months after operation, show failure of fusion, subluxation of the joint, eburnated bone ends, and less detritus in the joint and less synovial swelling.

across the front of the former joint. No actual graft was used from bone to bone. A plaster of Paris spica bandage was applied from toes of the left foot to the axillae. The operation was performed with a tourniquet.

Pathologic Report. "The specimen consists of many large and small pieces of bone and soft tissue from the left knee. The articular surfaces of the bone show much irregularity and absorption with production of new tissue. Microscopic examination: Sections show a fragment from the joint capsule including the synovial lining in which there is a chronic inflammatory process with numerous pigmented monocytes, foci of lymphocytes, thickening of the synovial layer, and irregular hyaline areas around the blood vessels. There is very marked thickening of the arterioles generally with very minute lumina and thick, muscular, and fibrous walls. This extends throughout the entire section with areas of mucoid degeneration around the vessels and in the fat. The bone and cartilage are irregularly mingled with calcification in the cartilage and fibrous trabeculae surrounding fragments of bone. Diagnosis: Chronic productive osteo-

temperature up to 104 degrees, which gradually subsided after one week. The wound was dressed through a window in the cast two weeks after operation. It was healed except for one small necrotic area. No discharge was noted.

Postoperative roentgenograms, February 1, 1937, showed a definite shift of the bone ends within the plaster splint, displacing the fusion area. On removal of the plaster, there were large pressure sores over the anterior crural region, the dorsum of the foot, and back of the knee. These showed every evidence of badly devitalized tissue. The sensation in the leg and foot was markedly impaired, and there was paralysis of the calf and anterior tibial muscles. The immobilization was continued with plaster of Paris while the patient was given intensive antiluetic treatment. The areas of skin necrosis slowly healed, and the patient left the hospital on April 14, 1937. At that time we were practically certain that fusion would not ensue. On June 14, 1937, the patient returned for a change of plaster, and this time the pressure sores were almost healed. On January 30, 1938, when the plaster splint was removed and a

brace applied, the patient was allowed to bear weight.

The latest examination, October 27, 1938, showed the skin entirely healed, sensation as good as in the other leg, and power regained in the muscles. The knee showed motion from full extension to 15 degrees of hyperextension. There was *no flexion as the subluxation blocked* this.

The patient gets around very well with a stiff knee brace. The failure to obtain fusion at the first operation has been previously noted in another case, but the extremely poor healing power in this patient makes us reluctant to try further surgery. (Figs. 4 and 5.)

COMMENT

In a few selected cases, fusion of these joints can be accomplished. In the first report by Cleveland and Smith[1] it was stated that firm fusion of three knees was obtained in from four to six months. Subsequent experience has not been so fortunate. During a prolonged period of postoperative immobilization, difficulties may arise, such as delayed union, poor healing of the skin, and failure to fuse as an end result in some instances, especially in advanced cases with marked destruction of the joint.

Since the first report in 1931, another knee joint has been successfully fused at the second attempt after seventeen months' immobilization. The knee joint reported herewith has failed to fuse, and a successful ankle fusion is reported. A total experience in fusing neuropathic joints may be summarized as follows:

	Successful	Failed
Knee joint..............	4	2
Ankle joint..............	1	0

This shows two failures out of seven attempts. Surgical fusion of these joints should not be casually attempted, as failure will almost certainly be fairly frequent.

It should be noted that no attempt has been made to search through medical literature for other experiences in the surgical treatment of these unstable neuropathic joints, so the comment submitted is based on a very small number of cases and is limited to purely personal experience.

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HYPERPARATHYROIDISM AND OSTEITIS FIBROSA CYSTICA*

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OUR first clear insight into the relation between cystic bone disease and disturbance of the parathyroids was in 1891, when von Recklinghausen studied the bones of two patients with malacia and thought that the lesions differed from osteomalacia. He realized that these lesions in his cases resembled those described by Engel in 1864 and by Langendorff in 1877. In 1884, seven years before von Recklinghausen's communication, Davis-Colley[1] described to the Pathological Society of London a typical case of osteitis fibrosa cystica. It is also interesting that Denninger recently uncovered a skeleton one thousand years old with general lesions of the bony structure typical of osteitis fibrosa.

While the difference between the malacia of the bones and cystic disease was recognized, the relation of the parathyroids was not mentioned. The first description of their function was in 1896 by Vassale and Generali,[2] who proved that tetany was the result of the removal of the parathyroids without removal of the thyroid. In 1904, Askanazy[3] published a careful study of a patient with multiple fractures of bones who also was found to have a tumor which he described as markedly different from the thyroid, and probably a parathyroid tumor. However, he failed definitely to associate the tumor with the bone lesions. Erdheim[4] interpreted the enlargement of parathyroids in rickets as a hyperplasia which indicated hyperfunction of the parathyroid. In 1904, Lundborg[5] suggested that myasthenia gravis might be due to hyperparathyroidism.

In 1925, Hoffheinz[6] collected cases of parathyroid tumor reported since 1900 and found twenty-five which were associated with lesions of the skeleton. Seventeen of them were osteitis fibrosa cystica. About this time, Berman and Collip,[7] independently, found the active principle of parathyroid capable of raising the serum calcium. Greenwald and Aub found that hypercalcemia caused by this extract was followed by increased secretion of calcium in the urine. In the same way, Mandl[8] transplanted a parathyroid into a patient suffering from fibrocystic disease but found that this aggravated the clinical signs. Afterward, he explored the thyroid region and removed a parathyroid tumor, with almost immediate improvement of the patient, with clinical lessening of calicum in the urine. Following this, many others, in the next eight to ten years, performed some one hundred operations to alleviate symptoms of von Recklinghausen's disease. This has led us to form a definite clinical entity of hyperparathyroidism suggested by Barr, later Jaffe and Blair,[9] who injected the parathyroid hormone in animals and produced bone lesions typical of fibrocystic disease.

SYMPTOMS

The disease itself is fairly rare, less common than Paget's disease. It is insidious and the onset covers a period of several years, advancing more rapidly in some patients than in others. The symptoms, in general terms, as related to the skeletal system, are pain referable to bones and joints of the lower extremities and the spine, even before deformities and fractures are seen. This pain is exaggerated by physical activity. As the disease progresses, spontaneous fractures and cysts may occur and may be the first intimation of serious disorder. Bony deformities, such as bowing,

usually occur later in the disease but vary with the location of the cyst and the weight-bearing part of the body involved.

blood calcium is ordinarily from 9.5 to 11.5 mg. per 100 c. c.; in hyperparathyroidism, it may vary from 12.5 to 29.4. In adults,

FIG. 1. Case 1. Lateral lower femur. A and B, before treatment (August 16, 1931). C and D, after treatment (September 12, 1932).

The lower extremities are most commonly affected. Kyphosis and scoliosis of the spine may be fairly common, but lesions here are not so common as in the long bones. One characteristic is that the height of the patient may diminish as much as 10 inches in a few years. Gradually, complete inability to walk is observed. This is associated with general symptoms of weakness, loss of appetite and weight, cardiac irregularities, hypochromic anemia, muscle and joint pains, usually severe and predominating in the back and legs.

Urinary symptoms are common, such as dysuria, renal colic, kidney stone, and diminished renal function. Metabolic and chemical manifestations are hypercalcemia, hypercalciuria, and increase in the serum or plasma phosphatase.

Females are apparently more affected with the disease than males. Most cases appear in middle adult life, between 30 and 55 years of age, but there are a few in childhood and extreme old age. Some children from 6 to 16 years of age have been reported.

Blood findings are usually, in typical advanced cases, increase of the serum calcium and decrease in the inorganic phosphorus salts. In normal persons, the phosphorus in the serum varies from 2.5 to 3.5 mg. per 100 c. c., a little higher in children; it is decreased in rickets, and osteomalacia, and in osteitis fibrosa cystica it sinks to a level of 1.5 to 2.5. These findings, of course, must be considered with the general symptoms of the disease.

From the laboratory standpoint, the following should be done: determination of serum calcium and inorganic phosphorus and serum phosphatase. Determination of the calcium and phosphorus balance of renal excretion of calcium.

McMurray[10] states that, "This condition is characterized by the replacement of bone by fibrous tissue and it occurs in two distinct types, which vary from each other in many essential features. The first is the localized type, where, in the skeletal structure, it occurs as a localized bone disease in one bone and is not associated with alteration in calcium or phosphorus metabolism, and may not be associated necessarily with parathyroid tumor. The second type is the generalized type, commonly recognized as von Recklinghausen's disease."

This "second type" is usually distributed generally throughout the bony structure and is characterized by many areas of bone change, and usually by definite

systemic disturbances of calcium and phosphorus metabolism. This is the type which is often recognized. The earlier

FIG. 2. Case II. Lateral os calcis. A, before treatment (December 2, 1932). B, after treatment (May 9, 1933). (From Merritt, in *Med. Ann., District of Columbia*, Nov. 1933.)

stages of the disease in the localized type are many times overlooked, or are not diagnosed as properly fitting into the picture of hyperparathyroid disturbance.

Hunter's[11] work, done years ago, has shown conclusively that the generalized type is associated with (a) hypercalcemia combined with a low phosphorus in the blood serum; (b) tumor of the parathyroid glands. The tumor is usually an enlargement and overgrowth of normal parathyroid tissue, which may be in the form of an adenoma and an increased secretion of the active principle of parathyroid gland, or parathormone, well known as a cause of disturbance in calcium metabolism.

In the excellent study of the parathyroids by Shelling,[12] the relations between hyperparathyroidism and osteitis fibrosa cystica are described as a symptom complex resulting from the increase of secretion of one or more parathyroid glands, or from the injection of parathyroid hormone, usually associated with a decreased response to stimuli of the neuromuscular system, demineralization and distortion of the skeleton, replacement of the osseus tissue in the marrow spaces by fibrous

tissue, and, in the advanced cases, showing cysts and giant cell tumors. It was also described as increased excretion of calcium

FIG. 3. Case III. Tumor of lower end of radius. Before treatment (March 15, 1934).

and phosphorus in the urine. This is associated with symptoms of immobilization with lime salts in the osseus system and the transporting through the channels of excretion. He divided the clinical types of the disease into the classical form: (1) with the typical osseus changes in which osteitis fibrosa cystica predominated; (2) the form characterized by decalcification of bone and osteoporosis, with no tendency to cyst or giant cell; (3) calcium deposit in the soft tissues, especially the kidneys. The distribution of these manifestations, which may be classified as types, depends on the disturbance in degree of hyperparathyroid abnormality and the duration of the disease, the age of the patient and dietary variations from normal. In the types where the skeletal system is involved, there is pain referable to the bones and joints, usually of the lower extremities and spine, preceding deformity and fracture. The condition increases so that there is marked and extreme hyperesthesia of the soft tissues, with an increase of pain by physical activity and by pressure. Later cysts are noted by x-ray study, of the long bones, or perhaps first in the jaw. The stature may be diminished, and, with the extremities affected, the gait may be disturbed. Symp-

toms which are referable to the kidneys and intestinal tract are suggestive of diabetes, polyuria, loss of weight, loss of ap-

FIG. 4. Case III (June 15, 1934).

petite, constipation, hypochromic anemia. Other cases may present renal colic and the associated symptoms of this condition. Chemical disturbances in the blood, urine and feces are not always present in the early stages of the disease, as quoted by McMurray.[10] Laboratory tests are sometimes of little value, since a number of cases have been reported in the literature where even in the advanced stage of the disease no appreciable chemical imbalance of calcium and phosphorus had occurred.

The disease is insidious in its onset, it is subject to remissions and may take years to develop to a degree sufficient to diagnose the actual conditions which exist, clinically and by blood examination. In a series of 115, Gutman, Swenson and Parsons[13] showed that the percentage of these patients with skeletal disturbance predominated over those with renal, gastrointestinal or other symptoms. Pain in the back and extremities predominated in 62 to 72 per cent of all the cases in the series, indicating that probably the largest percentage fall into the category of skeletal abnormality.

DIAGNOSIS

In the advanced cases, the diagnosis is not difficult. Lassitude, muscular hypo-

tonia, pain in the bones and joints, lumps in the bones, and urinary symptoms are present in the late case, but the early cases

FIG. 5. Case III (August 10, 1934).

with a single bone lesion are usually overlooked and may be confused with other conditions. It is these early cases, with the localized bone lesion, which are of particular interest because the general systemic symptoms are either not pronounced, or are not established sufficiently to become symptomatic, hence causing confusion as to the actual etiology of the disease.

From the standpoint of x-ray diagnosis, it is difficult many times to differentiate the disease because it may depend upon the duration, age, diet, location, posture, and other factors, as well as the degree of parathyroid hyperfunction. The appearance of small cysts or an osteoporosis of bone without other cause, the appearance of deformity, should be considered as possibly due to disturbance of the parathyroids.

The appearance of the calvarium in this disease varies a good deal, it may be thin as the result of the osteoporosis; it may be thickened in other areas, there may be cyst-like areas, or there may be a general granular and mottled appearance of bone. This is not necessarily characteristic of the disease. The vertebral bodies may be generally atrophied, granular, mottled, and osteoporotic, similar to the appearance in the skull. Later, they will be softened, narrowed, collapsed, and deformed, so-

called "fishbone" vertebrae, with later spinal deformity, either a kyphosis or scoliosis.

DIFFERENTIAL DIAGNOSIS

It should be borne in mind that hypercalcemia may be possible in diseases such as multiple myeloma, gout, metastatic carcinoma of the skeleton. The x-ray appearance of the bones in osteitis fibrosa cystica varies considerably, depending upon changes in pathology and duration of the disease and other factors such as age, diet, location of the lesion, also consideration of posture and weight-bearing. When there is deformity and expansion of the bone cyst, it is rather easy. The early appearance is sometimes difficult to determine and may resemble general osteoporosis or other atrophies or metabolic derangements. Pathologically, the appearance of the bones in osteitis fibrosa cystica indicates that the tendency to resorption and decalcification exceeds the tendency to new bone formation and it is a characteristic which distinguishes it from Paget's disease and most other malactic diseases of bone. Where doubt exists as to differentiation between cystic disease and giant cell tumor, a biopsy will usually clarify the diagnosis, although it is possible that many so-called giant cell tumors may in truth be fibrocystic disease.

Jaffe[9] states that the cyst may arise in the following ways: (1) from the degeneration of giant cell tumors as the result of hemorrhage and extravasation; (2) through stasis and dilatation of the lymph and blood vessels; or (3) through edema and degeneration of soft areas of fibrous marrow forming the bone cavity. Thompson and Collip feel that the action of the parathyroid hormone directly stimulates the osteoclast to erode the bone and liberate its calcium content. It has also been found that decalcification can appear in these cysts before the osteoclast.

Osteomalacia may sometimes be confused with fibrocystic disease and may show similar findings. However, recog-

nizing the etiologic factor, this confusion should not cause difficulty. Osteomalacia is a disease associated with deficiency in

Fig. 6. Case III, showing restoration of bony structure following x-ray treatments over the parathyroids only (January 21, 1935). (From the Warwick Memorial Clinic, Garfield Hospital, Dr. E. A. Merritt.)

lime salts and in vitamin D, with reduced concentration of calcium and phosphorus in the serum and the loss of calcium by way of the bowel, and with perfectly normal parathyroids.

In fibrocystic disease, the parathyroids are usually enlarged, calcium concentration in the serum is nearly always increased and the loss of calcium from the bones is chiefly through the kidneys. Vitamin D therapy fails to produce any benefit. In children, osteitis fibrosa produces bowing of the lower extremities and the growing bone, with widening of the metaphyses. These may be mistaken for late rickets, but the same criteria hold, as rickets, too, is essentially a result of vitamin deficiency.

In renal rickets, the renal impairment produces the bone changes. There is usually a history of nephritis or renal disease, stunting of growth long before skeletal deformities are evident. The resulting deformity is due to the removal of calcium by persistent chronic acidosis, the retention of phosphorus and its excretion in the bowel as the insoluble calcium phosphate, and the retention of non-protein nitrogen in the blood.

The osteoporosis of Cushing's disease, pituitary basophilism, usually is associated

with obesity, hypertension and amenorrhea. Multiple myeloma may cause confusion from the x-rays and chemical tests.

use of viosterol and vitamin B in large amounts. Aub, Albright, and others fail to note any influence of these measures on
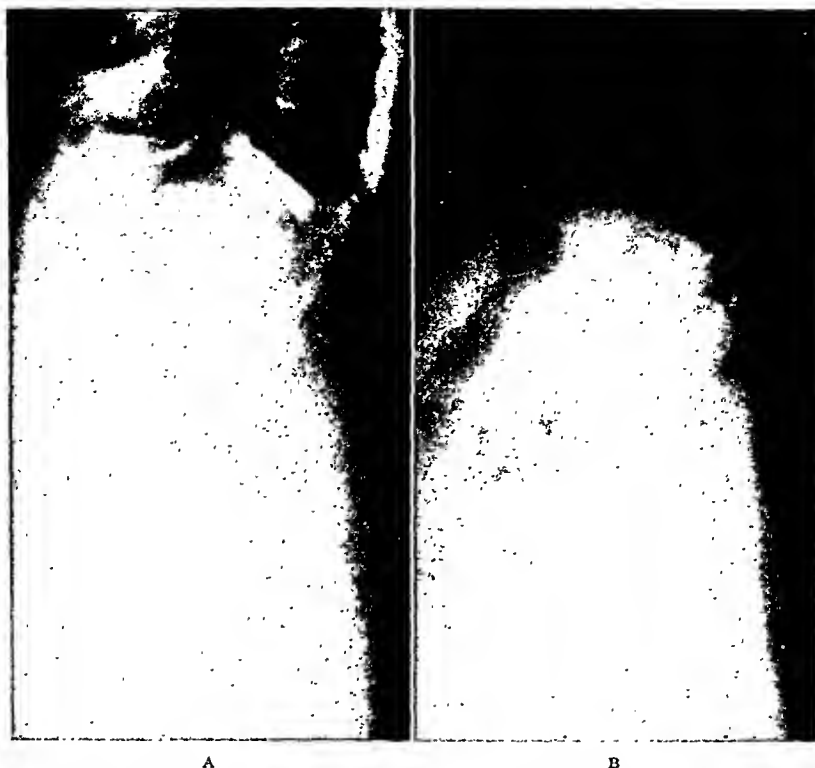
Fig. 7. Case IV. Showing extreme skeletal decalcification of spine. Relief of pain complete and locomotion restored. Loss of bone detail improved. A, October 29, 1935. B, March 24, 1936. (From Warwick Memorial Clinic, Garfield Hospital, Dr. E. A. Merritt.)

One differential point is that Bence-Jones bodies are nearly always present in multiple myeloma and absent in fibrocystic disease, but the only possible differentiation is by biopsy, x-ray studies, and x-ray therapeutic test by radiation of the parathyroids.

Osteogenesis imperfecta and fragilitas ossium are usually diseases of infancy. In the latter, blue sclerae are nearly always diagnostic, and the laboratory tests of the calcium and phosphorus are usually normal.

TREATMENT

In consideration of treatment of this disease, particularly in the early stages, we, of course, turn first to medical treatment. This would consist of the use of calcium gluconate or the calcium diet, massage, rest, and other measures; also the

the calcium and phosphorus balance, but they may aid in differentiating osteomalacia from fibrocystic disease. These temporarily may improve as the result of calcium administration.

Surgical treatment has been extensively discussed in the literature, and over 100 cures by this method have been described —the removal of parathyroid tumors and adenomas, and, in many instances, removal of perfectly normal parathyroids. The difficulties of removal of parathyroid tumors or abnormal parathyroid glands must be manifest because of the many abnormalities found in the distribution of these glands. Furthermore, a palpable tumor is not always found and the possibility of removal of the abnormal gland or glands renders surgical intervention hazardous and difficult. These abnormal locations

have been described in the literature by many authors, and increased difficulties of removal surgically of the tissues which may be the cause of the diseased bony structure. Ballin and Morse,[19] in their interesting paper, describe removal of normal parathyroids with clinical improvement. If there is a palpable adenoma, surgical removal may be simple, but one cannot be sure that the removal of this abnormal gland in itself is sufficient, as cases are recorded of several operative procedures in the search for abnormal tissue. The obliteration of the cystic area by surgery and packing with bone transplants may temporarily obliterate the cyst but recurrence, or the continuation of the disease in other bony structures is likely because of the failure of correction of the original cause of the cyst or cysts.

Cutler and Owen[14] advocate x-ray therapy under certain conditions, such as cases where there are contraindications to surgery, or as a postoperative method when a tumor is only partially removed, or when operation has failed to relieve the condition. It is known that the normal parathyroid tissue, as other normal tissues of glandular origin, is very resistant to radiation, and authorities claim that no case of tetany has ever been recorded as the result of x-ray therapy over the cervical region for abnormalities of either the thyroid or parathyroid glands. Theoretically, in young children and young adults, there is probably a young cell which becomes hyperplastic and produces an early lesion in the bony structure. This cell is usually described as very radiosensitive. Calcium and phosphorus metabolism after x-ray treatment does not negate the effectiveness of x-ray therapy, as sufficient cases have been reported in which bone lesion and all symptoms, local and general, were eliminated. It would seem logical to assume that the restoration of bone cystic areas by x-ray therapy over the parathyroids is of greater importance and diagnostic value than changes in phosphorus or calcium metabolism. It is well-known that x-ray

therapy over the bone cystic area is not curative in its effect, except possibly to increase scar tissue in the bone marrow.

Jacobs and Bisgard,[20] in a series of comprehensive articles and case reports, state, "The normal parathyroids are highly resistant to radiation, as has been shown experimentally and verified clinically. After exposure in treatment of the thymus, thyroid, or in cases of carcinoma of the larynx, no tetany develops even after intensive irradiation. That active hyperplastic cellular tissues are more radiosensitive is a well established fact attested by the efficiency of this form of therapy in influencing the salivary, ovarian, pituitary or thyroid functions. Merritt and McPeak believe that it would seem likely that adenomatous and hyperplastic parathyroid glands might respond similarly. Unfortunately, this is not the case, because irradiation has effected no cures or even temporary aid."

However, sufficient time has elapsed and follow-up of cases treated with x-ray by Merritt has shown complete relief of clinical signs and cystic regeneration in a number of cases, proportionate to successes following surgical removal of normal or abnormal parathyroid glands. Improvement in radiation technique applied in a series of treatments and covering both the normal and possible abnormal locations of the glands accounts for the satisfactory proved results in a sufficiently large number of cases which were found to be osteitis fibrosa cystica.

Merritt[15] reported in 1931, a first case of hyperparathyroidism treated by x-ray over the cervical region for a thyrotoxicosis, the patient having a multiple extensive bone lesion of the femur. Following the application of a number of x-ray treatments over the enlarged thyroid, the patient reported cessation of symptoms in the femur, and subsequent studies of this area show entire healing and restoration of practically normal contour of the entire bony structure. (Case 1.) Merritt recognized, at this time, the influence of irradiation upon the thy-

roid as well as upon the hyperparathyroids, influencing thereby the effect of disturbed calcium metabolism. His interest was aroused and he has treated a large number of similar cases with uniformly good results. He feels that the therapeutic test in itself is of value as a diagnostic procedure in bone lesions having the appearance of fibrocystic disease. Calcium and phosphorus estimations were made in a number of these patients but were never sufficiently altered to render confirmatory evidence of severe calcium or phosphorus disturbance.

Merritt and Lattman[16] have reported a series of cases, in some detail, in which they report seven cases further confirming the beneficial effects of x-ray therapy over the parathyroids, with the resultant lessening of local symptoms and x-ray confirmation of repair of fibrocystic lesions. They feel that any unexplained cystic bone disease, whether it be called a bone cyst, giant cell cyst, or fibrocystic disease, should be considered as due to hyperparathyroidism, and treated by x-ray until it is proved otherwise. Ewing has felt that giant cell tumor may be the end result of fibrocystic disease. He places it in the group of the hyperparathyroidism, although he seems to feel that it is in the group of osteitis fibrosa cystica generalisata.

Merritt[18] further states, concerning radiation of the parathyroid region: "Concerning radiation therapy in hyperparathyroidism, it may be stated that the parathyroids, like other ductless glands, are sensitive to radiation of moderate intensity when there is hyperfunction.

"The first case of hyperparathyroidism treated by me and, incidentally, the first one reported in the literature, remains perfectly well after more than six years.

"It is my definite impression that one may anticipate a quick relief from pain in all subjects who have well defined hyperparathyroidism, and failure to get this response has, I have found, been in those cases where there was considerable doubt as to the accuracy of the diagnosis.

"The several members of my group have treated sixty-nine cases to date.

"The Roentgen treatment of hyperparathyroidism is identical with that given for thyrotoxicosis and consists of four treatments on successive days over the neck anteriorly, which it may be necessary to repeat after an interval of six weeks. The area treated is sufficient to include that part of the cervical region where parathyroid glands are normally located. Tetany has never followed in any of our cases nor have we encountered this unpleasant sequela in any subject when the cervical region has been irradiated, even in the presence of doses which are ten to fifteen times greater than any we have ever employed in either hyperparathyroidism or hyperthyroidism."

SUMMARY

Early cases of hyperparathyroidism, with bone cyst, and typical skeletal changes, do not show characteristic high calcium blood findings associated with low phosphorus blood findings.

The therapeutics of x-ray over the parathyroids is valuable in determining the effectiveness of elimination of the bone cyst as a diagnostic procedure. The x-ray treatment of the parathyroids is simple and offers much less technical difficulty and more assurance of results than exploratory operative procedures in the search for the abnormality of the parathyroid gland or glands. The majority of the cases treated by Merritt and his co-workers, numbering sixty-nine, has shown permanency in the repair and relief of the skeletal changes, indicating the effectiveness of radiation treatment. Clinical relief of the advanced and more severely involved cases has been, in many instances, striking and should certainly be attempted before considering any surgical procedure either to the parathyroid glands or to the bony structure.

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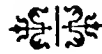
SENILE gangrene is the commonest form of gangrene in civil practice, occurring in both sexes after the age of fifty-five years. It usually affects the toes and feet, but is also met with in the hand, nose and ears.

TYPHOID AND PARATYPHOID OSTEOMYELITIS*

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TYPHOID osteomyelitis is truly a vanishing disease in America. In the early years of our country's existence, typhoid fever was a great menace, and, of course, all of its complications were noted. However, with the advent of successful immunization and the proper control of the water supply, typhoid and paratyphoid have become uncommon diseases. Less than 1 per cent of typhoid cases present bone lesions. In the most comprehensive review of the subject, Murphy reported an incidence of 0.8 per cent. In 1934, Veal and McFetridge reported two cases of paratyphoid osteomyelitis and were able to collect only sixteen other authentic cases from the literature. Therefore, it is not surprising that bone lesions complicating these two closely related diseases have become exceedingly rare.

Arthritis is an occasional complication of typhoid fever. The common sites are the stenoclavicular and the large joints, particularly the hip joint. The lesions are monarticular in about 90 per cent of the cases. The arthritis is most likely to occur during the active period of the typhoid fever, and usually is of the simple toxic variety. Sometimes, however, there is an actual bacterial invasion of the joint, and this may cause destruction of the synovium, cartilage, and even involve the bone. The joint becomes swollen, reddened, tender and painful. There is an effusion into the joint, the synovium is thickened, and the capsule is distended. When the hip joint is involved, subluxation is likely to occur unless measures are instituted to prevent it. In the toxic type of arthritis the effusion is sterile, and as the patient recovers from typhoid fever, the arthritis usually subsides. In the suppurative form, the effusion shows the typhoid organism, and the process may cause serious damage.

The treatment of typhoid arthritis consists of fixation of the joint with weight traction. When the effusion develops, the fluid should be aspirated and the joint irrigated with 1:1,000 or 1:500 solution of hypochlorite of calcium. When suppuration occurs, it may be necessary to incise and flush out the joint, but a drain should never be left in place; a primary closure should always be done. This procedure should be followed by the use of autogenous vaccine therapy.

One of the more frequent bone complications of typhoid fever is the so-called "typhoid spine." Murphy found the spine involved in 110 instances out of a total of 533 typhoid bone lesions. The lumbar vertebrae are involved in about 70 per cent of the cases. This complication usually becomes manifest during the immediate convalescent period of the typhoid fever. The main symptom is persistent backache which is not relieved by rest, even when lying quietly in bed. The pain is exaggerated on motion, and there may be tenderness over the involved vertebrae. The pain may be referred down the thigh and legs, and occasionally to the abdomen. There is usually a loss of the normal kyphosis, and scoliosis may develop. There may be rigidity and fixation of the spine, muscle wasting, cramps, and disturbance of peripheral sensation. Occasionally swelling may be present over the involved area. There may be x-ray evidence of thinning of the intervertebral disc with new bone formation. There may be a periosteitis, and the fibrous structures surrounding the spine may show inflammatory changes. The treatment consists of rest and prolonged fixation of the spine.

The most common bone lesion complicating typhoid is osteomyelitis. We have used the term "osteomyelitis" to include peri-

ostitis and osteitis, as well. The process may be acute, subacute or chronic in nature. Most frequently involved are the long bones, particularly the tibia, and next in order the ribs. When the long bones are involved, it is the diaphysis rather than the metaphysis that is affected. Typhoid bacilli have been found repeatedly in the bone marrow of patients dying from typhoid. While these organisms may be present in the bone marrow at the height of the fever, they seldom cause any recognizable evidence of bone disease during this period. In a few cases, however, they find suitable ground for continued growth and may survive after all evidence of the systemic infection has disappeared. These colonies remain dormant for a long period, and then suddenly come to life to produce active bone disease. Trauma to the bone may be the cause of the renewed activity of the organisms. The majority of cases of typhoid osteomyelitis occur months or years after the patient recovers from typhoid fever. Ebermaier reported a case in which the bone disease commenced on the thirteenth day of the fever, while in Gare's case, the osteomyelitis was first noted ten years after typhoid fever. Tubby and Hicks reported a case thirteen years, and Fogh reported one in which the osteomyelitis occurred twenty-seven years after recovery from typhoid fever. Because of this long delayed onset of the bone disease, typhoid is usually overlooked as the causative agent.

Typhoid osteomyelitis is not a single characteristic lesion. The invasion of the typhoid organism may result in bone necrosis or in bone formation. While many attempts have been made to classify these lesions, it is best to consider the various types as stages of the same process, or as Reimann so aptly puts it, "The specific typhoid, usually cortical, bone inflammations, shows various types according to relationship of absorption, caseation, liquefaction, or, rare, the formation of a central osteomyelitis with sequestrae."

The inflammation begins in the subperiosteal layer, then spreads to the intra-canalicular medulla and finally to the central medulla. The periosteum becomes thickened, swollen and injected, and is stripped up from the bone. If suppuration occurs, there is a collection of fluid beneath the periosteum. This fluid may be pus, or is sometimes serosanguineous in character. There may be no apparent necrosis of the adjacent bone, but the pus may be filled with small sequestrae. When the medullary cavity is involved, larger sequestrae may form. While the bone process is likely to remain localized, if suppuration occurs, it may break through the periosteum and form an abscess in the soft tissue and, later, even sinuses may develop. There is a peculiar type of abscess occasionally found in typhoid osteomyelitis—the so-called "collar-button" abscess. There is a subperiosteal collection of pus which communicates with the medullary cavity through a small opening in the bone, and in the medullary cavity there is another, larger collection of pus.

There are several distinguishing characteristics of typhoid osteomyelitis. The lesion is usually single, being multiple in less than 5 per cent of the cases. It is usually in the diaphysis of the long bones. The lesion is well-localized and shows little tendency to spread. It is usually a chronic or subacute type of infection, but occasionally becomes acute in character. There is seldom a mixed infection; even the draining sinuses of long duration may show a pure culture of typhoid bacilli. The disease usually runs an afebrile course. There is often a leucopenia, although in many cases the white blood cell count remains normal, and in a few there may be a leucytosis.

Pain is the outstanding symptom of typhoid osteomyelitis, either in the suppurative or nonsuppurative stages. It is dull, boring, in character, may be intermittent, and sometimes disappears without any treatment. In the suppurative form, however, the pain is more likely to persist and gradually a localized swelling develops.

Over the involved area there is tenderness on pressure. As the swelling occurs, there are usually other evidences of acute inflammation.

The diagnosis of typhoid osteomyelitis may be suggested by the finding of a localized area of osteomyelitis involving the diaphysis of the long bones in a patient with a previous history of typhoid. If in addition the course of the disease is non-febrile and there is an absence of leucytosis and a negative Wassermann, typhoid should be suspected. The x-ray is not characteristic, but the finding of a localized osteomyelitis that shows little tendency to spread would also suggest typhoid. The final diagnosis depends upon bacteriologic studies of fluid or pus obtained from the lesion itself. Agglutination tests are not conclusive.

The treatment of typhoid osteomyelitis depends upon the stage of the disease. In the nonsuppurative types or stage, simple rest and immobilization of the part, followed by vaccine therapy, will often cure the process. The stockroom typhoid vaccine, of course, must be used in this type of case. In the suppurative stages, surgery plus vaccines usually produces a cure. In the absence of sinuses, the whole area of the involved bone should be completely removed and the incision closed. This is followed by the use of autogenous vaccine made from the organism obtained from the lesion. When sinuses are present, these must be completely excised and the involved osseous tissue removed; when possible, the entire area should be closed without drainage. When the ribs and costal cartilages are involved, the entire segment must be excised. The prognosis is good.

Paratyphoid is closely related to typhoid and runs a similar course, but bone complications are exceedingly rare. Webb-Johnson found in a study of 1,038 cases of paratyphoid B fever only two instances in which the skeletal system was involved. The types of bone lesion caused by paratyphoid B bacillus are arthritis, osteitis, periosteitis and osteomyelitis. Just as in typhoid the sites of predilection are the sternoclavicular and the larger joints, the ribs, and the long bones, particularly those of the arm. The paratyphoid bone lesions differ from typhoid in some respects. In paratyphoid the disease is more acute, often runs a febrile course, and there is more often a leucytosis. The bone lesions occur during or very soon after recovery from the systemic infection and are frequently multiple. When the long bones are involved, the process begins in the diaphysis, but is likely to spread through entire length of the bone. The earliest lesions, as demonstrated by x-ray findings, consist in thickening and elevation of the periosteum. After the process has developed to suppuration there is little to distinguish it from the staphylococcus or streptococcus osteomyelitis except that the shaft of the bone is more involved than the metaphysis.

The diagnosis of paratyphoid osteomyelitis depends upon the characteristic agglutination tests, and the identification of the organism from the blood stream or pus from the lesion. Agglutination tests alone should not be relied upon for a positive diagnosis.

The treatment consists in incision and drainage. It is usually impossible to remove all the diseased tissue because of the extent of the lesion. Following adequate drainage autogenous vaccines should be tried. The prognosis is not as good as in typhoid osteomyelitis. The multiplicity of the lesions, and often the presence of a systemic infection, as well, points toward a lowered resistance to that particular organism.

SUMMARY

Typhoid and paratyphoid bone complications are indeed rare. Any part of the skeletal system may be involved, but the sites of predilection are the sternoclavicular and large joints, the long bones, the ribs, and the spine. The joint lesions are usually non-suppurative but a true pyoarthrosis may occur. The bone pathology may be that of a periosteitis, osteitis, or osteomyelitis and may be suppurative or non-suppurative in character. In both

typhoid and paratyphoid the osteomyelitis begins in the diaphysis and not in the metaphysis. In typhoid osteomyelitis the lesion is usually single and well localized and runs a chronic course. In paratyphoid the disease spreads through the entire shaft, is usually multiple, and more acute in character. The diagnosis depends upon bacteriologic studies of the pus or fluid removed from the bone lesion. Serologic tests are not reliable.

The treatment of the arthritis is simple aspiration or surgical evacuation of the fluid from the joint with primary closure. The treatment of the typhoid osteomyelitis consists of removal of the diseased bony tissue, primary closure of the wound, and autogenous vaccine therapy. Open drainage is usually necessary in the paratyphoid osteomyelitis because of the extent of the disease. Following drainage autogenous vaccines should be used.

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A BIOCHEMICAL INVESTIGATION OF ARTHRITIS*

PRELIMINARY REPORT ON URIC ACID, GLUTATHIONE, AND SULFUR IN THE BLOOD; AND SULFUR IN THE URINE

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THIS paper is intended as the first report of a long series of investigations being conducted by the authors in the hope of establishing some biochemical evidence of the relationship of sulfur metabolism with arthritis.

One of the authors (Wheeldon) reported previously his success with injectable sulfur preparations as one phase in the treatment of arthritis.[1] Other reports have appeared in the literature substantiating this claim.[2,3,4,5,6] Its beneficial effects continue to be noted by one of the authors, and as reported recently,[7] appear to be enhanced and supported when the preparation is administered in conjunction with an adrenal cortex preparation. As previously reported by one of the writers in an earlier paper, it is not to be assumed that only sulfur therapy is used by him in any given case. The matter of diet, improvement in body mechanics, removal of foci of infection, etc., is carried out in all cases. An observation made by Grüneberg while using adrenal cortex therapy in the treatment of psoriasis is interesting in this connection and lends support to our views.[8,9] This author views psoriasis as in many cases due in part to an adrenal deficiency syndrome. The excellent results which he had obtained using adrenal cortex therapy have since been confirmed by Kissmeyer (quoted by Grüneberg[9]). Grüneberg states that the most remarkable effects have been secured in the treatment of psoriasis arthropatica, noting also in most cases complete recovery of the joint symptoms.

These observations become particularly interesting when account is taken of the work of certain French, German and Italian investigators, who have attempted to demonstrate the rôle of the adrenal cortex as a regulator of sulfur and glutathione metabolism. The reports are somewhat scattered and difficult of evaluation, and as yet no theoretical review of the whole field has appeared in the literature. Consequently, only a brief summary of the claims will be made here:

Several workers have reported a high sulfur content (percentage) for the adrenals, particularly the cortex.[10,11,12] Others[13,14,15] have reported a high glutathione value (percentage). Adrenalectomy (even unilateral) and Addison's disease are said to produce a high blood sulfur, particularly of the neutral fraction (reference has usually been made to the serum),[11,16] and a low blood glutathione.[14,15,17]

Administration of adrenal cortex in normal animals produces the opposite effects: a low serum sulfur[16]; and a high blood glutathione.[14,18]

The suprarenal vein is reported to contain considerably less serum sulfur than the artery, thus suggesting a thiopexic function for the adrenals.[19] On the other hand, glutathione concentration in the suprarenal vein exceeds that in the artery.[20] Experimentally, the adrenal glands appear to have pronounced powers of synthesizing glutathione.[20] Following adrenalectomy, a lowering of glutathione in the muscles and organs has been demonstrated.[14] Injec-

tion of sulfur and sulfur-containing compounds increases the sulfur content of the adrenals.[21] This was noted to an even greater extent using sulfur salve.[12,22] The cartilage of old animals is reported to show a low sulfur content.[23] Low and unchanged glutathione blood values have been reported in arthritics.[23,24] A low neutral sulfur of joint cartilage together with high total blood sulfur values is claimed in cases of arthritis.[23] Following sulfur introduction into animals, a rise in blood glutathione occurred, out of all proportion to the amount of sulfur administered.[25]

The majority of the above reports were unknown to the authors when the present biochemical investigation was begun, but their discovery has served only to speed plans to uncover a suggested relationship between arthritis, adrenals, sulfur metabolism and possibly glutathione metabolism.

A new sulfur preparation is being used in the present investigation. The authors feel that the more accurate standardization of this preparation and the higher degree of colloidal dispersion, together with the clinical effects noted, make this preparation preferable to those previously used.

The mechanism by which the sulfur preparations exert their action is a matter of speculation. One of the authors has suggested that the underlying cause in arthritis is a general sulfur deficiency, and that by some mechanism sulfur preparations aid in building up the sulfur reserve.[1,7] The sulfur content of the finger nails has been used as an index of the general sulfur level in the body. It is extremely doubtful that the sulfur administered affects this level in a direct way, since the total amount of sulfur employed is very small in comparison with the total sulfur content of the human body. It is far more likely that its effect is a catalytic stimulation of the sulfur metabolism within the body, or that it in some way increases the absorption of the sulfur of normal nutrition. If its effects are due entirely to colloidal properties, some other element might serve the same purpose equally well. That the actual sulfur nature of the preparations is of importance would seem suggested on the basis of the possible tie-up between the adrenal cortex, sulfur metabolism and arthritis.

Sullivan explained the therapeutic value of sulfur on the basis of a detoxification process, the sulfur administered sparing the natural sulfur reserves of the body, which were otherwise drained in combating the arthritic condition.[26]

As a possible explanation of the mechanism of the sulfur action, we must mention the recent work of Hans Selye on the "alarm reaction," a specific physiologic reaction of the organism to various injurious agents, such as drugs, toxic preparations, excessive muscular exercise, surgical injuries, etc.[27,28] The reaction involves many at least of the symptoms of adrenal cortex deficiency, with adrenal enlargement perhaps the most characteristic feature. The reaction represents a defense mechanism. In time, the animal becomes adapted to the injurious agent, if the damage has not been too severe. Very possibly colloidal sulfur elicits the same response, and the adrenal hypertrophy may be the direct mechanism for counteracting the arthritic condition.

Földes noted a conspicuous enlargement of the adrenals resulting from the continued administration of sulfur salves. At the same time the sulfur content of the adrenal showed sevenfold absolute increase and a 100 per cent increase in sulfur concentration.[22]

Monaghan and Garai looked upon their sulfur preparation as an active germicide, capable of sterilizing the blood and controlling bacteremias.[4]

In presenting a preliminary report of the biochemical results thus far obtained, the authors are fully cognizant of the many variables involved, of the difficulties of attempting to present an accurate analysis of clinical changes as related to biochemical values, and of the limited significance of the results. Nevertheless, it was felt that they might prove of interest both to biochemist and physician.

The standardization of the conditions of the experiment have thus far proved very difficult and, as developed, far from ideal. Many of the subjects were out of town patients, some receiving their sulfur injections from other doctors. The coöperation of the arthritic patient in many cases was hardly all that could be desired.

The cases were selected because of the pronounced state of the arthritis, and though some had received previous treatment, at the time of the initial work-up the arthritic condition was sufficiently marked to warrant inclusion in the series. The great majority of the patients did not receive a second work-up during or following the period of treatment so that our attention must be directed in this report mainly toward the biochemical make-up of the arthritic and not to the effects produced by the treatment employed.

EXPLANATORY NOTES FOR CHARTS

1. The values presented in the charts are arranged in columns 1, 2, 3, 4; the values of corresponding columns representing analyses made on the same sample of blood or urine. The period of time elapsing between the analyses varied and so is not indicated. The analyses of column 1 are referred to in the paper as "initial" analyses. This term is also extended to include a limited number of other values as noted on page 603 in the section on Blood Glutathione. The values of columns 2, 3, 4, are referred to as "other than initial."

2. A limited number of analyses in the charts are accompanied by an asterisk, and these values are referred to in the paper as doubtful analyses. This designation does not necessarily indicate an erroneous result, and means merely that some doubt was introduced due to the time elapsing between withdrawal of the blood and its analysis, or some other similar detail. These values are not included in average results unless indicated.

3. In most cases the urine specimens were collected on or within a day or two of the time of the corresponding blood analysis.

4. Approximately 20 c.c. of blood was withdrawn from the venous circulation for each series of analyses.

5. When given, the sulfur preparation was administered slowly by the intravenous route. The largest doses of 2 c.c., containing 20 mg. of sulfur in a high state of dispersion, were well tolerated by the patients.

6. All hemoglobin determinations were made by the Newcomer method.

BLOOD REDUCED GLUTATHIONE

In a limited number of arthritic cases Loeper reported low blood reduced glutathione values.[23] Senturia, in a much larger series, was able to find no essential variation from the normal.[21] Our results confirm those of Senturia, but we feel that certain precautionary measures in the future may possibly alter this conclusion. Binet and Weller state that digestion materially affects the blood level of glutathione.[29] The method of Benedict and Gottschall which we have used gives a wide range of normal values, from 31 to 48 mg. per 100 c.c. of blood.[30] Binet claims by a more specific method to have found a normal range of 17 to 25 mg. per 100 Gm. of blood.[15] The use of such a method might make abnormal values of much greater significance. It is also felt that a practical method for determining the oxidized as well as the reduced fractions of glutathione would add materially to the value of the test.

TABLE 1
INITIAL GLUTATHIONE ANALYSES

No. of Cases	Type of Arthritis	Average Mg. Per Cent
28	Hypertrophic	39.9
32	Proliferative	38.9
5	Mixed	37.8
1	Proliferative-dessicans	45.0
1	Mixed, hypertrophic predominating	36.0
7	Analysis doubtful	45.6
74	Average of all cases	39.9
54	Average of all cases not including doubtful analyses nor those which had received sulfur previously, except in a few cases where sulfur was given a year or more previously	40.5

CHART I

	Case Number	Sex	Age	Type of Arthritis	Blood Reduced Glutathione (Mg/100 C.c.) (GSH)				RBC Count (Millions)				Hemoglobin Per Cent (HBG)				GSH/RBC				GSH × HBG / RBC			
					1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
N. M. C.	1	F	53	H	40	39	43	34		4.2	4.5			92	83			9.3	9.6			8.5	7.9	
G. A. W.	2	F	46	H	43	46	38																	
W. E. C.	3	M	64	H	36	47	36		5.0				80				9.4					7.5		
E. G. C.	4	F	51	H	*40	*53	32																	
W. J. T.	5	M	62	M	32				4.7				73				6.8				5.0			
L. G. A.	6	F	64	P	31	47			4.2				62				7.4				4.6			
E. M. G.	7	F	49	P	32	34			4.0				58				8.0				4.6			
F. L. B.	8	F	35	P	31	36							94											
C. W. B.	9	F	66	H	32	25																		
E. B. S.	10	F	63	H	28	21							77	82										
M. E. B.	11	F	22	P	59																			
G. E. T.	12	F	53	H	*34																			
A. S. P.	13	F	70	H	50																			
A. P. N.	14	M	46	P	30																			
J. M. H.	15	F	61	P	*45																			
R. V.	16	F	54	H	38				4.5				78				8.4				6.6			
J. W. G.	17	F	51	P	41				4.1				82				10.0				8.2			
J. A. H.	18	F	42	P	53																			
A. R. B.	19	F	39	P	43				4.3				70				10.0				7.0			
L. E. B.	20	F	47	P	46								86											
C. L. P.	21	F	40	M	40				5.0				80				9.2				7.4			
A. M. H.	22	F	38	P	50				3.9								12.8							
C. K. L.	23	F	70	P	47	34																		
H. H. F.	24	F	27	P-D	45	42																		
W. H. B.	25	M	16	P	34	39				4.5				76				8.7				6.6	
N. S. M.	26	F	15	P	41	35			4.6	4.0			66	80			8.9	8.7			5.9	7.0		
F. N. M.	27	F	53	H	41	33																		
G. J.	28	F	39	H	42	42							80											
G. W. T.	29	F	63	H	..								83											
E. C. H.	30	F	52	P	45	31			3.4				70				13.2				9.3			
G. S.	31	M	61	P	33																			
J. P. P.	32	F	67	H	43																			
N. E. McD.	33	F	52	M	*38				4.0				80				9.5				7.6			
A. H.	34	F	53	H	34																			
H. C. R.	35	F	38	P	37				3.7				75				10.0				7.5			
P. B. P.	36	M	46	P	32																			
C. J. A.	37	F	48	M	45																			
G. H. S.	38	F	56	P	37				4.0				78				9.3				7.2			
W. P. D.	39	M	61	H	39								86											
J. M. B.	40	F	47	M	38																			
A. J.	41	F	47	H	48				4.5				80				10.7				8.5			
G. H. W.	42	F	61	M-H	36																			
H. L.	43	M	47	H	29																			
G. J.	44	M	47	H	26																			
L. H. R.	45	F	35	P	34																			
R. E. B.	46	F	68	H	26																			
G. T. E.	47	F	47	H	28																			
E. M. D.	48	F	57	P	35				3.5				65				10.0				6.5			
J. L. F.	49	M	15	P	35				4.2				70				8.3				5.8			
E. L. M.	50	F	61	H	45								71											
M. B. H.	51	F	53	P	*61																			
M. S. B.	52	F	39	P	46																			
T. E. M.	53	F	35	H	*51																			
S. D. T.	54	F	61	P	48				4.0				90				12.0				10.8			
E. P. J.	55	F	60	H	50				4.0				84				12.5				10.5			
M. W. T.	56	F	59	P	30				4.0				78				7.5				5.9			
B. G. S.	57	M	57	H	54				4.6				84				11.7				9.9			
C. P. K. B.	58	M	60	P	39				4.8				85				8.1				6.9			
S. W. R.	59	F	44	P	39				4.2				83				9.3				7.7			
F. R. S.	60	F	47	H	54				4.5				90				12.0				10.8			
B. M. W.	61	F	38	H	23	28							71	88										
A. G.	62	M	59	H	50																			
B. N. H.	63	F	36	M	*50																			
D. A. G.	64	M	67	P	32																			
H. M. G.	65	F	35	P	..				4.6				89											
W. V. M.	66	M	17	P	38				4.0				80				9.5				7.6			
L. F.	67	F	51	H	36																			
J. E. H.	68	F	31	P	35				4.5				75				7.8				5.8			
M. W. H.	69	F	46	H	45				5.0				95				9.0				8.6			
A. H. S.	70	M	50	P	32																			
R. F. B.	71	F	40	P	42	36																		
S. G. W.	72	F	61	P	42				4.4				73				9.5				7.0			
H. H. H.	73	F	51	H	46				4.5				75				10.2				7.7			
W. M. F.	74	F	60	M	34																			
W. E. S.	75	F	57	H	45																			
K. M. H.	76	F	44	P	42				4.0				79				10.5				8.3			

The above results are based on the initial analyses in those cases where more than one analysis was made on a patient.

The method of Benedict and Gottschall was used in analyzing for blood reduced glutathione. These authors obtained an average of 39.5 mg. per cent for eight normal cases with values ranging from 31 to 48. The average of 39.9 which we have obtained points to a normal glutathione level in arthritis. The values in the fifty-four cases above ranged from 26 to 59. Of how much value such results are where the range of normals is so wide remains a matter of question. If the glutathione level is in any way an indication of the metabolism of the individual, and if each individual is maintained on his own specific level among a wide range of normals, it would be of little value to compare his glutathione level with the general average.

In our series, Cases 11, 13, 18, 22, 55, 57, 60, 62 had initial glutathione analyses of 50 mg. or above. Cases 10, 43, 44, 46, 47, 61 had initial glutathione analyses below 30 mg.

In the first group five cases were hypertrophic, three proliferative. The patients in this group were thought to be decidedly more stable, possessing more determination, were less introspective, and probably more of a reasoning type than those of the second group.

All six cases of the second group were hypertrophic. The most striking thing was the remarkable improvement made by all of this group, in contrast to the first group in which there were two cases of no improvement, four of moderate improvement,

one of remarkable improvement, and one case of no follow-up.

Cases 6, 9, 20, 43, 46, 47, 56, 61, 62, 64, 67, 72, 76 had received sulfur treatment sufficiently recent before the initial analysis

TABLE III

RISES IN GLUTATHIONE FOLLOWING THE ADMINISTRATION OF SULFUR

Case No.	Amount of Sulfur Given between Analyses	Initial	Final	Change	No. Weeks between Analyses
2		43	46	3	15
3		36	47	11	26
4	From 20 c.c. to 100 c.c.	40*(S)	53	13	10
6		31 (S)	47	16	16
7		32	34	2	5
8		31	36	5	14½
25		34	39	5	16½
		247	302	55	
	Average...	35.3	43.1	7.9	

* Doubtful analysis.
(S) Sulfur given previous to initial analysis.

TABLE IV

DEPRESSIONS IN GLUTATHIONE FOLLOWING THE ADMINISTRATION OF SULFUR

Case No.	Amount of Sulfur Given between Analyses	Initial	Final	Change	No. Weeks between Analyses
1		40	39	− 1	14½
2		46 (S)	38	− 8	15
4		53	32	−21	12
9	From 20 c.c. to 113 c.c.	32 (S)	25	− 7	16½
10		28	21	− 7	14½
23		47	34	−13	8½
24		45	42	− 3	25
27		41	33	− 8	24
71		42	36	− 6	30
		374	300	−74	
	Average...	41.6	33.3	− 8.2	

to warrant considering a possible influence on the glutathione values. A summary of these cases follows, but the number is too small to permit conclusions.

TABLE II

SUMMARY OF CASES

No. of Cases	Type of Arthritis	Glutathione Average Mg. Per Cent
6	Proliferative	37.2
7	Hypertrophic	32.0
13	Average of all	34.4

TABLE V

NO CHANGE IN GLUTATHIONE FOLLOWING THE ADMINISTRATION OF SULFUR

Case No.	Amount of Sulfur Given between Analyses	Initial	Final	Change	No. Weeks between Analyses
28	40 c.c., except last two weeks	42	42	0	8

TABLE VI

SUMMARY OF TABLES III, IV, AND V

No. of Cases	Variation	Total Change (Mg. Per Cent)	Average Change (Mg. Per Cent)
7	Rise	55	7.9
9	Depression	−74	−8.2
1	No change	0	0
17		−19	−1.1

TABLE VII

VARIATIONS IN GLUTATHIONE, ALTHOUGH NO SULFUR ADMINISTERED BETWEEN ANALYSES

Case No.	Initial	Final	Change	No. Weeks between Analyses
1	39 (S)	43	4	9
1	43 (S)	34	− 9	8½
3	47 (S)	36	−11	7½
26	41	35	− 6	23
30	45	31	−14	8½
61	23 (S)	28	5	16
	238	207	−31.0	
Average....	39.7	34.5	− 5.2	

TABLE VIII

A SUMMARY OF TABLE VII—VARIATIONS IN GLUTATHIONE ALTHOUGH NO SULFUR ADMINISTERED BETWEEN ANALYSES

No. of Cases	Variation	Total Change	Average Change	Initial Average	Final Average
2	Rise	9	4.5	31.0	35.5
4	Depression	−40	−10.0	44.0	34.0

A limited number of cases is presented in which an attempt was made to follow the variation in level of glutathione as a possible function of the sulfur therapy given: Cases 2 and 4 appear in both the table of rise and the table of depression, and the designation initial signifies merely the glutathione analysis at the start of that particular period of sulfur administration.

The two cases in which there was a rise and two of the cases in which there was a depression had received sulfur previous to the initial analysis.

Of the seven cases showing a rise in reduced glutathione following sulfur therapy, six showed definite clinical improvement. Of the nine cases showing a depression, eight also showed definite clinical improvement.

In two other cases receiving no sulfur between determinations, an increase in reduced glutathione was noted and both showed clinical improvement during this time. In four similar cases, showing decreased glutathione values, improvement also took place. In the two cases in which there was a rise and in two of the four showing a decrease, sulfur had been given previous to the initial analysis.

SUMMARY BASED ON TABLES III TO VIII

1. In seventeen cases, during the administration of sulfur, glutathione rises totalling 55 mg. per cent and depressions totalling minus 74 mg. per cent, with an algebraic total of minus 19, occurred. In one case there was no change. On the basis of these data it would seem that sulfur treatment has no specific effect on glutathione level in the blood.

2. There was an average change for both rises and depressions of 7.9.

3. The initial analysis of those cases in which there was a rise averaged 35.3. The initial analysis for those cases in which there was a depression averaged 41.2.

4. The average variation in those cases in which no sulfur treatment was given between analyses was slightly less than the variation (positive or negative) that took

place during sulfur treatment: 5.2 as compared with 7.9.

5. From the seventeen cases referred to:

Highest at start..................... 53
Highest at end...................... 53
Lowest at start..................... 28
Lowest at end....................... 21
Greatest rise....................... 16
Smallest rise.......................   2
Greatest fall....................... 21
Smallest fall.......................   1

6. In the limited number of cases presented no specific influence of sulfur treatment on the glutathione level of the blood can be ascertained.

TABLE IX
COMPARISON OF GLUTATHIONE INITIAL VALUES IN MALES
AND FEMALES

No. of Cases	Sex	Average in Mg. Per Cent
16	Males	35.7
51	Females	40.4
7	Biochemical analysis doubtful	
74		

The above results suggest that females possess a higher glutathione level than males. If one considers the glutathione values of arthritics to be normal, then this conclusion would apply to both normal and arthritic individuals. This is in accord with the findings of Villela, Campos and others.[31] Woodward and Fry, however, found no difference in the glutathione level of the two sexes in a series of fourteen normal females and sixteen normal males.[32]

TABLE X
EFFECT OF AGE ON GLUTATHIONE VALUES

No. of Cases	Age	Average in Mg. Per Cent
39	50 or above	39.7
35	Below 50	39.6
17	Below 40 (included in the 35 above)	40.8
6	Below 30 (included above)	42.0

Previous findings have been contradictory as to the effect of age on glutathione values.[33,34,35] No great differences for the group as a whole are found.

TABLE XI
INFLUENCE OF RED BLOOD COUNT

No. of Cases	Red Blood Count	Average Mg. Per Cent
14	4,500,000 or more	43.4
19	less than 4,500,000	39.4
12	4,000,000 or less (included above)	39.9

The results in Table XI suggest that red blood counts greater than 4,500,000 have the effect of raising the glutathione values. This might seem to follow from the fact that glutathione is thought to exist almost exclusively in the red blood cells with little, if any, in the plasma. The effect as noted above, however, seems relatively slight. Woodward and Fry determined an average glutathione value of 33.7 for nine normal patients whose red blood count was below 5,000,000 and 34.1 in fourteen where the count exceeded 5,000,000.[32]

TABLE XII
GABBE'S QUOTIENT

$$\frac{\text{Reduced Glutathione}}{\text{Red Blood Count}} = \frac{\text{GSH}}{\text{RBC}}$$

No. of Cases	Range	Average GSH/RBC	Average GSH	Average RBC	Woodward and Fry Quotient $\left(\frac{\text{GSH} \times \text{HBG}}{\text{RBC}}\right)$
33	6.8–13.2	9.5	40.9	4,300,000 (4.3)	7.5 (32 cases)

Gabbe's quotient expresses the glutathione content of the blood per unit number of red blood cells.[36] Woodward and Fry, using their method of analysis, found a GSH average for thirty normal cases of 34 (covering the range of 25 to 41 mg. of GSH per 100 c.c. of blood) with a Gabbe's quotient of 6.8. Their average red blood count was 5.1.

Woodward and Fry had noted that in certain cases where the hemoglobin color

TABLE XIII

GABBE'S QUOTIENT COMPARED WITH THE RED BLOOD CELLS

No. of Cases	Red Blood Count	Gluta-thione Average Mg. Per Cent	Aver-age RBC	Gabbe's Quo-tient	HBG*	W. & F. Quo-tient*
14	4,500,000 or more	43.4	4.7	9.3	80.0	7.5
19	less than 4,500,000	39.4	4.0	9.9	76.0	7.4

* Only eleven and eighteen cases respectively are included in the compilation of the hemoglobin and Woodward and Fry's quotient.

index was high the glutathione was low and vice versa, and thought that by incorporating the hemoglobin figure in Gabbe's quotient a rough expression of the oxidizing power of the red blood cell per unit number of cells might be obtained.

Gabbe found that whereas there was no significant variation in the glutathione content of the whole blood in secondary and pernicious anemia, there were increases in Gabbe's quotient, particularly so in the latter group, thus indicating that the glutathione content of the individual cell had increased. This was in line with his other experiments, showing a large increase in the glutathione content of the individual corpuscle in hemorrhage or phenylhydrazine anemia or following a lowering of the partial pressure of the oxygen of inspiratory air. This was taken to mean a compensatory increase in oxidizing power of the individual cell where the total number of cells was decreased.

Whereas the groups listed above show no great difference in red blood counts, Gabbe's findings are confirmed inasmuch as his quotient is found to increase with a decrease in red blood count, thus indicating an increase in the reduced glutathione content of the individual cell.

URINARY SULFURS

The following values have been obtained by various workers[37] for total sulfur excretions over a twenty-four hour period:

	Gm.
Stadelmann	.94
Gruner	.60 to .94
Krause	.54 to .86
Clare	.74 to 1.19
Sick	.88 to 1.24
Finbinger	.76 to 1.28
Neubauer	.68 to 1.28
Allen and Neuberg	1.0
Folin	1.32
Padoa	1.05
Hawk and Bergeim	1.0

Folin's patients were kept on a diet fulfilling the so-called dietary standards. He also determined averages for the various sulfur fractions:

	In-organic Sulfur, Gm.	Ethereal Sulfur Gm.	Neutral Sulfur, Gm.
Per cent of total sulfur...	1.17 (87.8)	.09 (6.8)	.07 (5.1)

Rather widely varying normal values have been reported for the percentages of total sulfur appearing as neutral sulfur:[37]

Folin	5.1
Salkowski	16.3
Stadthagen	14.
Lepine	20.
Heffter	24.3 to 26.9 (Meat diet)
Heffter	31.1 to 33.1 (Bread diet)
Guitars	19.41 to 21.14
Halpern	20. to 25.

This discrepancy is not surprising when one considers that the absolute neutral sulfur excretion remains relatively constant while the total sulfur excretion varies widely with the diet. The neutral sulfur excretion is to be compared with the constant creatinine excretion.

In spite of the careful work of Folin most clinical workers have considered as more representative, normal values of 10 to 20 for this percentage value.

Cawadias found an increase in total sulfur excretion in his rheumatoid arthritics.[38] Against normal values of 1 to 1.2 Gm. per twenty-four hours, these patients showed values ranging from 1.6 to 2 Gm. The total sulfur: total nitrogen ratio was increased in these cases from a normal of

CHART II

Case Number	Name	Urine Total Sulfur (ST) Gms./24 Hrs.				Urine Total Sulfate (SO) Gms./24 Hrs.				Urine Neutral Sulfur (SN) Gms./24 Hrs.				Urine Inorganic Sulfate (SIO) Gms./24 Hrs.				Urine Etheral Sulfate (EtSO) Gms./24 Hrs.				Urine SN/ST (Per Cent)				Urine SO/ST (Per Cent)				Urine SIO/SO (Per Cent)				Urine Volumes (C.C.) per 24 Hrs.(?)			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	N. M. C.	.46	.62	.61	.63	.42	.51		.55	.04	.11	.09	.08	.39	.44	.46	.48	.01	.07	.08	.07	8	17	14	13	92	83	86	87	93	86	89	87	550	690	740	595
2	G. A. W.	.67	.69	.87		.58	.56	.52		.09	.13	.10		.53	.49	.71		.05	.06	.07		13	19	11		87	81	89		91	88	92		2000	2310	2500	505
3	W. E. C.	.34	.70	.74		.28	.63	.77		.06	.07	.11		.26	.59	.59		.02	.04	.04		18	10	15		82	90	85		93	94	94		1340	770	1080	
4	E. G. C.	.16	.47	.41		.095	.33	.63		.065	.14	.13		.065	.29	.22		.03	.04	.06		41	30	32		59	70	68		68	88	79		200	3545	3300	
5	W. J. T.																																				
6	L. G. A.	.57	.60			.54	.48			.03	.12			.45	.44			.08	.04			5	20			95	80			83	92			950	1100		
7	E. N. G.	.61	.70			.49	.53			.13	.17			.41	.47			.08	.06			20	24			80	76			84	89			2300	2040		
8	F. L. B.	1.08	.93			.95	.79			.13	.14			.89	.75			.06	.04			12	15			88	85			94	95			1300	1300		
9	C. W. B.	.55	.49			.50	.38			.05	.11			.34	.34			.16	.04			9	22			91	78			68	00			1065	1785		
10	E. B. S.	1.06	1.16			.90	1.01			.16	.15			.87	.90			.03	.02			15	13			85	87			97	98			2140	2050		
11	M. E. B.	.95				.78				.17				.75				.03				18				82				96				1580			
12	G. E. T.																																				
13	A. S. P.	.84				.70				.14				.66				.04				17				83				94				820			
14	A. P. N.	.57				.47				.10				.42				.05				16				82				89				1710			
15	J. M. H.	.57				.57				.10				.45				.02				17				83				96				760			
16	R. V. G.	.27				.23				.04				.22				.01				15				85				96				290			
17	J. W. G.	.75				.63				.12				.53				.10				16				84				84				1225			
18	J. A. H.	.43				.29				.14				.24				.05				33				67				83				1575			
19	A. R. B.	.41				.33				.08				.29				.04				20				80				88				1320			
20	L. E. B.	.49				.40				.09				.37				.03				18				82				93				2330			
21	C. L. P.	.83				.73				.10				.66				.07				12				88				90				1650			
22	A. M. H.																																				
23	C. K. L.	.36	.21			.32	.18			.04	.03			.27	.17			.05	.01			11	14			89	86			84	05			493	352		
24	H. H. F.	.42	.47			.40	.37			.02	.10			.28	.32			.12	.05			5	21			95	79			70	87			960	1430		
25	W. H. B.	.37	1.23			.32	1.01			.05	.22			.25	.09			.07	.09			13	18			87	82			78	91			?	?		
26	N. S. M.	1.00	.51			.67	.44			.32	.07			.43	.39			.25	.05			33	14			67	86			64	89			?	3050		
27	F. N. M.	.42	.68			.34	1.52			.08	.16			.31	1.47			.03	.06			19	10			81	00			91	97			?	1750		
28	G. J. H.	.73	.66			.62	.58			.11	.08			.57	.52			.05	.06			15	12			85	88			92	90			1280	1700		
29	G. W. T.	.38	.82			.32	.50			.06	.32			.31	.43			.01	.07			16	37			84	61			97	86			1645	955		
30	E. C. H.	.26	.33			.20	.31			.06	.02			.15	.27			.05	.04			23	6			77	94			75	87			510	2140		
31	G. S.	1.34				1.20				.14				1.14				.06				10				90				95				960	735		
32	J. P. P.	1.80				1.70				.10				1.65				.05				16				94				97				990			
33	N. E. McD.																																				
34	A. H.	.47				.40				.07				.37				.03				15				85				93				580			
35	H. C. R.	.43				.36				.07				.33				.03				16				84				92				870			
36	P. B. P.	.45				.31				.14				.27				.04				31				69				87				1740			
37	C. J. A.	.87				.76				.11				.68				.08				13				87				89				1660			
38	G. H. S.	1.22				1.12				.10				1.04				.08				8				92				93				1565			
39	W. P. D.	.70				.58				.12				.53				.05				17				83				91				685			
40	J. M. B.	.43				.35				.08				.28				.07				19				81				80				900			
41	A. J.	.58				.47				.11				.42				.05				19				81				89				1660			
42	G. H. W.	.71				.57				.14				.54				.03				20				80				95				1970			
43	H. J.	.80				.67				.13				.64				.03				16				84				96				930			
44	G. J.	.50				.41				.10				.40				.01				18				82				98				1225			
45	L. H. R.	.45				.38				.07				.30				.08				16				84				79				1060			
46	R. E. B.	.41				.40				.01				.37				.03				2				98				93				815			

CHART II.—(Continued)

Case Number	Name	Urine Total Sulfur (ST) Gms./24 Hrs. — 1	Urine Total Sulfate (SO) Gms./24 Hrs. — 1	Urine Neutral Sulfur (SN) Gms./24 Hrs. — 1	Urine Inorganic Sulfate (SIO) Gms./24 Hrs. — 1	Urine Ethereal Sulfate (EtSO) Gms./24 Hrs. — 1	Urine SN/ST (Per Cent) — 1	Urine SO/ST (Per Cent) — 1	Urine SIO/SO (Per Cent) — 1	Urine Volumes (C.C.) per 24 Hrs.(?) — 1
47	G. T. E.	1.10	.90	.2	.85	.05	18	82	94	1670
48	E. M. D.	.46	.38	.08	.30	.08	17	83	79	750
49	J. L. F.	.80	.69	.11	.66	.03	14	86	89	1800
50	E. L. M.	.64	.50	.14	.44	.06	22	78	80	735
51	M. B. H.	.22	.18	.04	.16	.02	18	82	89	440
52	M. S. B.	.55	.52	.03	.41	.10	5	95	79	895
53	T. E. M.	.33	.26	.07	.24	.02	21	79	92	675
54	S. D. T.	.51	.41	.10	.29	.12	20	80	71	2275
55	E. P. J.	.75	.65	.10	.59	.06	13	87	91	2395
56	M. W. T.	.35	.30	.05	.27	.03	14	86	90	580
57	B. G. S.									
58	C. P. K. B.	.86	.67	.09	.63	.04	22	78	94	1580
59	S. W. R.	.71	.55	.16	.47	.08	23	77	85	?
60	F. R. S.	.86	.69	.17	.63	.06	20	80	94	3085
61	B. M. W.	1.47	1.24	.23	1.19	.05	16	8.4	96	2845
62	A. G.	1.16	1.11	.05	.81	.30	4	96	73	?
63	B. N. H.	.32	.24	.08	.20	.04	25	75	83	660
64	D. A. G.	1.11	.90	.21	.81	.09	19	81	90	2025
65	H. M. G.	.57	.51	.06	.40	.11	10	90	78	?
66	W. V. M.	.84	.72	.12	.70	.02	14	86	97	1330
67	L. F.	.69	.60	.09	.51	.09	13	87	85	950
68	J. E. H.	.64	.55	.09	.49	.06	14	86	89	1775
69	M. W. H.	.56	.42	.14	.42	.00	25	75	100	828
70	A. H. S.									
71	R. F. B.	.23	.17	.06	.10	.07	16	74	59	755
72	S. G. W.	.68	.57	.10	.44	.13	17	83	77	?
73	H. H. H.	.58	.45	.13	.40	.05	22	78	89	1345
74	W. M. F.	.89	.76	.13	.70	.06	15	85	92	?
75	W. E. S.	.44	.35	.09	.33	.02	20	80	94	?
76	K. M. H.	.72	.61	.11	.54	.07	15	85	89	?
76	K. M. H. (2)	.70	.55	.15	.48	.07	21	79	87	?

1:7–1:10 to 1:3.[39] Assuming a normal value of .07 Gm. for ethereal sulfate excretion, he noted an increase in the case of

that there was a definite inability of the tissues to retain sulfur, as evidenced by the high excretion.

TABLE XIV
INITIAL URINARY ANALYSES
(Average in Gm. per Twenty-four Hour Specimen)

No. of Cases	Vol. of Urine	Total Sulfur (ST)	Total Sulfate Sulfur (SO)	Inorganic Sulfate Sulfur (SIO)	Ethereal Sulfate Sulfur (EtSO)	Neutral Sulfur (SN)	SN/ST* (Percentage)	EtSO/SO* (Percentage)
5	less than 500 c.c. (includes a 510 c.c. specimen)	.28	.23	.21	.02	.05	20	13
22	500–1,000 c.c.	.53	.46	.41	.05	.07	15	14
11	1,000–1,500 c.c.	.70	.61	.55	.06	.09	16	11
14	1,500–2,000 c.c.	.77	.64	.59	.05	.13	18	9
7	2,000–2,500 c.c.	.74	.62	.55	.07	.12	17	12
2	over 2,500 c.c.	1.17	.97	.91	.06	.20	18	5
9	Volumes unknown	.73	.61	.49	.12	.12	17	19
56	Average of all except those of unknown volume and below 500 c.c.	.68	.57	.48	.05	.11	16	12
34	Average of all except those of unknown volume and below 1,000 c.c.	.76	.64	.59	.06	.12	17	10

* These values represent averages of the individual percentages.

TABLE XV
URINARY ANALYSES OTHER THAN INITIAL
(Average in Gm. per Twenty-four Hour Specimen)

No. of Cases	Vol. of Urine	Total Sulfur (ST)	Total Sulfate Sulfur (SO)	Inorganic Sulfate Sulfur (SIO)	Ethereal Sulfate Sulfur (EtSO)	Neutral Sulfur (SN)	SN/ST* (Percentage)	EtSO/SO* (Percentage)
1	less than 500 c.c. (includes a 510 c.c. specimen)	.21	.18	.17	.01	.03	14	5
6	500–1,000 c.c.	.59	.52	.46	.06	.08	12	11
3	1,000–1,500 c.c.	.67	.55	.50	.04	.12	19	9
4	1,500–2,000 c.c.	.87	.74	.70	.05	.11	15	8
4	2,000–2,500 c.c.	.84	.65	.60	.05	.19	23	10
4	over 2,500 c.c.	.75	.60	.54	.07	.15	20	13
1	Volumes unknown	.70	.55	.48	.07	.15	21	13
21	Average of all except those of unknown volume and below 500 c.c.	.73	.60	.55	.05	.12	17	10
15	Average of all except those of unknown volume and below 1,000 c.c.	.78	.64	.59	.05	.14	19	10

* These values represent averages of the individual percentages.

arthritis deformans.[39] The ratio of neutral sulfur to total sulfur, contrary to his former report, was not disturbed. Thus he assumed that sulfur oxidation was undisturbed, but

Race found the S:N ratio to be essentially unchanged. He noted that in a rather large percentage of his forty-two cases of rheumatoid arthritis the excretion of

neutral sulfur exceeded the assumed maximum normal of .12 Gm.[40]

Goldthwaite, Painter, and Osgood reported a case of hypertrophic arthritis in the active stage in which they demonstrated a marked tendency of the tissues to retain sulfur.[41]

The classical gravimetric methods of Folin and of Benedict for urinary sulfurs, as set forth by Hawk and Bergeim, were used in this investigation.[42]

Because of the wide variations in urine volumes brought in as representing twenty-four hour specimens and because some of the specimens undoubtedly did not represent true twenty-four hour specimens, the volume groupings of Tables XIV and XV were made. Volumes larger than 1,000 c.c. were considered as representing true twenty-four hour specimens. Among the initial urinary analyses there were thirty-four such specimens. In subsequent analyses made on some of these same individuals fifteen such specimens were obtained.

It is interesting to note the large number of urine specimens brought in which did not exceed 1,000 c.c. In almost all cases specific instructions had been given the patients regarding the method of collecting the urine. A possible low urine excretion in the case of arthritics is suggested.

In a series of forty-nine analyses on forty individuals (based on twenty-four hour specimens of known volumes and exceeding 1,000 c.c.), an average total sulfur (ST) excretion of .77 Gm. was obtained (Tables XIV and XV combined). In an additional twenty-nine analyses, with volumes between 500 and 1,000 c.c. (probably only a limited number represented twenty-four hour specimens), an average of .54 Gm. was obtained.

This average of .77 Gm. should presumably be considered low or low normal on a basis of comparison with the normal values enumerated above.

The ethereal sulfate (EtSO) averages of .06 and .05 Gm. ("initial" and "other than initial" averages) are normal or low normal, as compared with Folin's normal

average of .09 Gm. and Hawk and Bergeim's .04 to .1 Gm.

The neutral sulfur (SN) values (average .12 and .14 Gm.) should probably be considered normal or high normal. These values are somewhat higher than Folin's average of .07 Gm., but lie well within the range of .08 to .16 Gm. given by Hawk and Bergeim. Only eight of the thirty-four cases among the initial urinary analyses lay without this latter range.

With low total sulfur values, approximately normal ethereal sulfate sulfur values, and normal or high normal neutral sulfur values, it follows that the low total sulfur values must be due to low inorganic sulfate sulfur (SIO). The averages of .59 and .59 Gm. ("initial" and "other than initial" averages) are somewhat lower than Folin's average of 1.17 Gm. and Hawk and Bergeim's .72 Gm.

The percentage of total sulfur expressed as neutral sulfur (averages 17 and 19) lies in the high normal range, as would be expected from the slightly low total sulfur and perhaps slightly high neutral sulfur values.

TABLE XVI
SUMMARY OF NEUTRAL SULFUR VALUES IN THE
TWENTY-FOUR HOUR SPECIMENS WITH VOLUMES
EXCEEDING 1,000 C.C.—INITIAL ANALYSES

No. of Cases	Volume of Urine	Average Gm. per 24 Hour Specimen
34	All volumes above 1,000 c.c.	.12
Variations from the Average		
11	Plus variations	.05
20	Neg. variations	.03
3	No variations	.00
34	Average of all	.03

1. The neutral sulfur excretion for the twenty-four hour period appears to be relatively constant, an average of .12 Gm. being secured in thirty-four initial analyses on thirty-four arthritics. The average

CHART III

Number	Name	Blood Uric Acid Mg./100 C.c. Blood				Blood Inorganic Sulfate (Old Method) Mg. S/100 C.c. Serum				Blood Total Sulfate (Old Method) Mg. S/100 C.c. Serum				Blood Inorganic Sulfate (New Method) Mg. S/100 C.c. Serum				Blood Total Sulfate (New Method) Mg. S/100 C.c. Serum				Inorganic Sulfate (Variation from New Method) Mg. S/100 C.c. Serum				Total Sulfate (Variation from New Method) Mg. S/100 C.c. Serum			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	N.M.C.	2.4	3.7	4.2	4.0	2.4	4.4	4.2	2.1	3.7	7.5	7.4	3.4															−3.1	+1.2
2	G.A.W.	1.5	3.6	2.1		1.3	5.2	3.3		3.0	7.2	8.3																+5.9	
3	W.E.C.	2.7	2.8	1.7	2.7	2.1	2.0	1.9		3.0	4.0	6.7																	
4	E.G.C.		*2.7			3.2	4.0																						
5	W.J.T.	4.0	4.0				3.4	4.4			6.7																		
6	L.G.A.	3.3	2.0			3.4	2.6			10.3	10.6																		
7	E.M.G.	1.6	2.5			2.1	3.0			6.4	6.4																		
8	F.L.B.	2.7	1.5			1.9	2.5			4.8																			
9	C.W.B.	2.2	1.3			1.9	3.0			4.9	6.3																		
10	E.B.S.	3.3				2.8				*7.9																		.7	
11	M.E.B.	*2.6				*3.5				1.4	7.9				.8			2.7		.6				−1	.1				
12	G.E.T.	1.8				1.1					1.4			*.8	1.1	1.6	.8	*4.0	4.5				+	+	1.2				
13	A.S.P.	3.3				1.8					3.8			1.3				4.3		.3				+	.4				
14	A.P.N.	*3.2				1.9					4.2			.7				1.9		.2				1	.6				
15	J.M.H.	3.0				1.0					3.2			.4				2.0		.3									
16	R.V.	3.4				.6					2.4			1.4				7.4											
17	J.W.B.	3.1				1.1					8.0																		
18	J.A.H.	4.1				2.8					9.9																		
19	A.R.B.	2.5				3.2					5.5																		
20	L.E.B.	3.4															0											.5	
21	C.L.P.																1.4												
22	A.M.H.	3.3	3.3			2.2	2.4			6.3	.9						−.8												
23	C.K.L.	3.3	2.6			2.9	.7			2.2	6.4																		
24	H.H.F.	4.4	3.4			1.6	3.7			5.3	5.5						3.0												
25	W.H.B.	5.0	3.1			4.1	1.7			6.6	1.6	5.5						6.0	2.9										
26	N.S.M.	2.7	2.8			1.2	2.7			4.2	4.2				1.1	1.1			1.0		+1.7	.8					+2.3	+1.3	
27	F.N.M.	3.1	3.1			1.0	.8			8.3					.9					+1.2									
28	G.J.					2.8	1.8																						
29	G.W.T.	2.0	2.3			2.1				13.7																			
30	E.C.H.	2.7				5.4				*8.9																			
31	G.S.	2.4				*2.4																							
32	J.P.P.	*3.6																											
33	N.E.McD.																												

A. H.	34	2.6			2.9			3.1		2.0
H. C. R.	35	3.1			.9			1.7		1.1
P. B. P.	36	3.3								2.5
C. J. A.	37	4.1								
G. H. S.	38	2.7			1.1			2.1		
W. P. D.	39		3.7	2.6	3.8			13.7	5.5	
J. M. B.	40	2.7			3.7			8.5		
A. J.	41	3.9			3.3			12.1		
G. H. W.	42	2.4			4.0			8.2		
H. J.	43	4.4			2.6			7.2		
G. J.	44	2.7			1.9			6.6		
L. H. R.	45	2.6			1.6			3.5		
R. E. B.	46	1.6			1.6			4.1		
G. T. E.	47	2.2			1.9			6.4		
E. M. D.	48	3.2								
J. L. F.	49	2.7			4.1			5.6		
E. L. M.	50	2.3			3.8			12.6		
M. B. H.	51	*3.3			*1.0			*3.5		*2.6
M. S. B.	52	2.0			2.0			1.6		
T. E. M.	53	1.7			3.2			13.0		
S. D. T.	54	2.5			2.0			11.2		2.7
E. P. J.	55	4.0			5.4			10.9		
M. W. T.	56	2.3			3.1			9.0		6.5
B. G. S.	57	3.2			2.1					
C. P. K. B.	58	2.4			1.1			6.0		2.7
S. W. R.	59	3.0			1.0			3.5		2.2
P. R. S.	60	3.1	1.3		3.5			5.4	5.4	
B. M. W.	61	2.7			2.6	3.7				
A. G.	62	2.9			2.5			1.6		
B. N. H.	63	3.4			3.8			5.8		
D. A. G.	64	3.0			1.2			1.6		
H. M. G.	65	2.0			2.7					
W. V. M.	66	4.4			3.7			6.6		
L. F.	67	2.4			2.3			10.7		
J. E. H.	68	2.4			.9					3.0
M. W. H.	69	2.0								1.6
A. H. S.	70	3.3	2.4		.7			1.7		
R. F. B.	71	3.3			2.0	1.3		6.1		
S. G. W.	72	4.3			3.1					.9
H. H. H.	73	3.1			1.8					
W. M. F.	74	3.7			2.2			5.9		
W. E. S.	75	3.2			*1.9			3.9		
K. M. H.	76	3.2						*3.8		

variation from the .12 was .03 Gm. (an average plus variation of .05 and a negative variation of .03).

2. Eleven values exceeded the average variation of .03 with variations of:

−.06 (1,340 c.c.)	.04 (2,140 c.c.)
−.07 (1,065 c.c.)	.05 (1,580 c.c.)
−.04 (1,320 c.c.)	.08 (1,670 c.c.)
−.04 (1,280 c.c.)	.05 (3,085 c.c.)
−.05 (1,060 c.c.)	.11 (2,845 c.c.)
1,213 c.c. (average)	2,224 c.c. (average)

The average volume for the remaining twenty-three cases was 1,717 c.c.

These results lead us to one of two conclusions, both of which are interesting: (1) The high volumes (2,224 c.c.) and the low volumes (1,213 c.c.) do not represent true twenty-four hour specimens. If we excluded these cases the absolute neutral sulfur excretion would show a much narrower range of individual variation; or (2) in some way the neutral sulfur excretion is tied up with the volume of urine excreted.

In order to determine whether any essential differences existed between the two types of arthritis so far as pertained to the sulfur excretions, these were calculated separately for total and neutral sulfur for known volumes above 1,000 c.c.

TABLE XVII
INITIAL URINARY ANALYSES
(Gm. per Twenty-four Hour Specimen)

Type of Arthritis	No. of Cases	Total Sulfur	Neutral Sulfur
Proliferative............	17	.72	.12
Hypertrophic............	14	.81	.12

TABLE XVIII
URINARY ANALYSES OTHER THAN INITIAL
(Gm. per Twenty-four Hour Specimen)

Type of Arthritis	No. of Cases	Total Sulfur	Neutral Sulfur
Proliferative............	5	.79	.14
Hypertrophic............	9	.81	.15

No significant differences are seen to exist.

BLOOD URIC ACID

By the Folin[43] and Benedict[44] methods for uric acid determination in blood, normal values range from 2.5 to 5 mg. per 100 c.c. of blood. Folin's direct method was used in our investigations, with normal values ranging from 2 to 3.5 mg. per 100 c.c. of blood.[45]

Maizels and Payne reported an increase in uric acid in eight out of fifteen cases of rheumatoid arthritis.[46] Race, out of a series of several hundred cases of arthritis deformans, noted an increase in 79 per cent of males and 58 per cent females.[46] Folin and Denis (1915); Pratt (1916); and Horowitz (1916) frequently noted high values.[46] Chase, Meyers, and Kilian; Koplin; and Freund found only normal values.[46]

Our analyses have revealed no abnormalities in the uric acid blood level of arthritic patients.

TABLE XIX
URIC ACID DETERMINATIONS—INITIAL ANALYSES

No. of Cases	Type of Arthritis	Average in Mg. Per Cent of Blood
32	Proliferative	3.0
28	Hypertrophic	2.7
6	Mixed	3.6
1	Proliferative-dessicans	3.3
1	Mixed—hypertrophic predominating	2.4
4	Biochemical analyses doubtful	3.2
72		
4	No analyses	
76		
72	Average of all analyzed	3.0
	Range of values	1.5–5.0

Among the initial analyses there were, out of seventy-two, only nine cases which exceeded 4.0 mg. per cent and none of these exceeded 5.0 mg. per cent. Five cases fell in the low range, 1.5 to 2.0 mg. per cent.

Cases with values of 4.0 to 5.0 mg. per cent: No. 5, 19, 25, 26, 37, 43, 55, 66, 72.

Cases with values of 1.5 to 2.0 mg. per cent: No. 2, 7, 13, 46, 53.

The above results lead to the conclusion that the uric acid blood level of arthritic patients is absolutely normal.

BLOOD SULFUR

A. Inorganic Sulfates of Serum. The great diversity of results obtained for normal values is well seen in the table which Hoffmann and Cardon incorporate in their paper.[47]

Author	Precipitating Agent	Method	Range of Values (Mg. S per 100 C.c. Serum)
Denis............	Barium	Nephelometric	0.5–1.0
Kahn and Postmontier........	Barium	Volumetric	1.0–3.0
Yoshimatsu.......	Benzidine	Colorimetric	2.0–3.3
Loeb and Benedict............	Barium	Gravimetric	0.7–1.6
Wakefield........	Benzidine	Colorimetric	0.2–0.9
Cuthbertson and Tompsett......	Benzidine	Colorimetric	0.1–0.5
Wakefield Powers and Keith......	Benzidine	Oxidometric	0.8–1.7
Macy............	Benzidine	Oxidometric	1.1–1.9
Hoffmann and Cardon........	Benzidine	Oxidometric	0.3–1.1

Of the various methods experimented with in the present investigation:

Hoffmann and Cardon[47]; Cope[48]; de Meio's modification of Cope; Letonoff and Reinhold[49]; and other methods have been carefully studied. The method of Letonoff and Reinhold appears to be the most practical and the most accurate. The method of Cope was employed throughout the greater part of the investigation, but was finally discarded because of its unreliability and apparent inaccuracy. The results of these analyses are included only for completeness and for comparison with the values obtained later with the method of Letonoff and Reinhold. A direct comparison between the two methods can be made in a limited number of cases in which both methods were employed.

TABLE XX
INORGANIC SULFATES OF SERUM OF ARTHRITIC PATIENTS

No. of Cases	Method	Average in Mg. S per 100 C.c. Serum
19 (initial analyses)...........	Letonoff and Reinhold	.9
10 (other than initial)........	Letonoff and Reinhold	1.1
62 (initial analyses)...........	Cope	2.4
22 (other than initial)........	Cope	2.7

TABLE XXI
COMPARISON BETWEEN LETONOFF AND REINHOLD, AND COPE METHODS

Variation of results (Cope method) from results (Letonoff and Reinhold method) in those cases in which both methods were employed

No. of Cases	Variation	Average in Mg. S per 100 C.c. Serum
1	None	.0
4	Negative	.4
19	Positive	.9
24	Average	.6

On the basis of twenty-three normals in the age limit of 20 to 24 years, Letonoff set forth the normals of his method as .95 to 1.16 mg. of sulfur per 100 c.c. serum with an average of 1.04. In a series of fourteen normals we obtained an average of .7 mg. On a basis of these normals and those of Letonoff and Reinhold's, there seems little reason to assert that the average values of .9 and 1.1 (see above) obtained in twenty-five different arthritic cases are anything but normal.

Table xxi readily reveals the lack of concordance between the two methods employed. It is believed that the method of Letonoff and Reinhold yields accurate results.

B. Total Sulfates of the Serum. These results are included for the sake of completeness. The methods employed proved neither reliable nor accurate, and all of the results must be discarded.

Since no practical published method for determining total sulfates was known to the authors at the start of this investigation, an attempt was made to adapt the methods of Cope, and Letonoff and Reinhold to this purpose, following a preliminary hydrolysis of the ethereal sulfates. The ethereal sulfates were hydrolyzed with hydrochloric acid, but the subsequent formation of benzidine chloride in acetone on the addition of benzidine to the hydrolyzed filtrate caused high results. It was difficult to prevent burning if the hydrochloric acid was driven off by heat before addition of the benzidine. Decolorization of the dry residue with hydrogen peroxide produced variable results, and in the case of the Cope method much of the sulfate was apparently lost as sulfur dioxide.

A summary of the results is found in Table XXII.

TABLE XXII
TOTAL SULFATES OF THE SERUM OF ARTHRITIC PATIENTS

No. of Cases	Method	Average in Mg. S per 100 C.c. Serum
51 (initial analysis)	Adaptation of Cope	6.0
20 (other than initial analyses).	Adaptation of Cope	5.8
17 (initial analyses)	Adaptation of Letonoff and Reinhold	2.9
9 (other than initial analyses).	Adaptation of Letonoff and Reinhold	3.4

C. Normal Values with the New Method of T. V. Letonoff for the Fractionation of Blood Sulfur. Recently methods have been suggested to us by T. V. Letonoff for total sulfates and total sulfur of the serum, which preliminary investigations indicate to be practical and probably accurate.

These methods are to be published soon in the Technical Supplement of the *American Journal of Clinical Pathology*.

TABLE XXIII
NORMAL VALUES
(Obtained with the unpublished methods of T. V. Letonoff*)

Total Non-protein Sulfur of Serum (ST) Mg. S per 100 C.c. Serum	Total Sulfates of Serum (SO) Mg. S per 100 C.c. Serum	Neutral Sulfur SN = ST − SO Mg. S per 100 C.c. Serum
1. 4.1	1.7	2.4
2. 2.9	1.0	1.9
3. 3.2	1.6	1.6
4. 3.8	1.6	2.2
5. 1.7	1.4	.3†
6. 3.3	1.1	2.2
7. 3.7	1.1	2.6
8. 2.9‡	2.0	.9
8. 2.3	1.1	1.2
8. 2.3	1.9	.4

Other Total Sulfur Normal Values	Other Total Sulfate Normal Values
2.9	1.3
5.3	1.1
2.1	1.2
3.7	1.3
3.4	

(ST) Average of Normals (15 Series of Analyses on 13 Persons)	(SO) Average of Normals (14 Series of Analyses on 12 Persons)	(SN) Average of Normals (10 Series of Analyses on 8 Persons)
3.2	1.4	1.6

* Published with Dr. Letonoff's permission. Thanks are due to Mr. William Willis, Jr., who carried out the work on Dr. Letonoff's unpublished methods.

† Extremely stout person with urticaria.

‡ Values obtained from blood of a normal drawn on three successive days in late afternoon.

CONCLUSIONS

1. No abnormal variation in the average reduced blood glutathione value of seventy-four arthritic patients could be ascertained.

2. A slightly higher average reduced blood glutathione value was found in the case of females as compared with males.

3. No essential age variations in the glutathione values were revealed.

4. A series of thirty-four arthritic patients showed an average reduction in the urine sulfate sulfur excretion.

5. These same patients showed average neutral sulfur and ethereal sulfate sulfur values which were essentially normal.

6. Seventy-two arthritics showed normal blood uric acid values.

7. The average of blood inorganic sulfate values of twenty-five arthritic patients, determined by the method of Letonoff and Reinhold, appeared to be normal.

8. Normal values for total sulfur and total sulfates of the blood, determined by a new method, are presented.

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CASE HISTORIES

Case 1: Hypertrophic.

Masculine type of woman. Improvement has been very satisfactory with respect to arthritis. Recently she has become somewhat nervously unstable.

Case 2: Hypertrophic.

Has extreme condition of lassitude. Arthritic improvement has been marked, but still suffers from lassitude.

Case 3: Hypertrophic.

A generalized involvement at the start. Patient very asthenic. Arthritis has improved greatly. Patient is now looking the world in the face and looking forward to work.

Case 4: Hypertrophic.

Patient was almost totally disabled and nervously unstable. Her recovery has been almost complete from a clinical standpoint. The patient is still nervously unstable.

Case 5: Mixed.

Arthritic involvement was greatly advanced. Patient highly emotional from a clinical stand-point. Arthritis has been cleared up, but the patient is still somewhat of an emotional type.

Case 6: Proliferative.

Patient somewhat of a masculine type, with very advanced arthritis. No improvement.

Case 7: Proliferative.

A very generalized involvement disabling patient. Patient is highly emotional and suffers from lassitude. There are no follow-up notes.

Case 8: Proliferative.

There was an early localized arthritis with a certain amount of suffering from lassitude. Arthritis improved; no change in mental outlook.

Case 9: Hypertrophic.

Patient was almost incapacitated, highly emotional and introspective. Marked improvement. Patient has become stable, and is now conducting the business of a large dairy farm.

Case 10: Hypertrophic.

Patient was very asthenic with marked arthritis. Her recovery has been unusually rapid and sustaining.

Case 11: Proliferative.

Moderate, early somewhat generalized involvement. No follow-up notes.

Case 12: Hypertrophic.

A severe arthritic involvement. Patient somewhat of a stolid type. Arthritis has been improved but character unchanged.

Case 13: Hypertrophic.

A stolid, phlegmatic person, confined to bed when first seen. When last seen, able to be brought long distances in an automobile.

Case 14: Proliferative.

Suffering from lassitude and markedly involved arthritis. No follow-up notes.

Case 15: Proliferative.

Patient riddled with arthritis and characterized by lassitude. Was out of tune with the world. Arthritis now much improved and patient definitely more stable.

Case 16: Hypertrophic.

Patient had a severe arthritic involvement; was highly emotional. Arthritis now improved. Outlook the same.

Case 17: Proliferative.

Patient was riddled with arthritis with a very poor outlook. Very introspective. Now markedly improved, takes interest in the world. Libido has become very marked in spite of her age.

Case 18: Proliferative.

A timid, introspective person with all joints involved and marked deformity. Was confined

to a wheel chair. Patient is now walking, but still timid and nervous; however, no longer introspective.

Case 19: Proliferative.

Early, but severe generalized involvement, highly emotional sexual type.

Case 20: Proliferative.

Generalized, moderately advanced involvement. A stable businesslike woman. Arthritis now much improved, but character unchanged.

Case 21: Mixed.

Arthritis markedly advanced; patient neurotic and highly emotional. Has been unchanged in either respect; refusing to take treatment.

Case 22: Proliferative.

General, severe involvement. Hardy working type. No nerves. Clinical improvement has been remarkable.

Case 23: Hypertrophic.

Highly incapacitated. Irritable sort of person. Arthritis much improved. Patient has become very stable.

Case 24: Proliferative-dessicans.

A generalized involvement of moderate intensity. An ambitious type of person. Improvement has been slow, but continuous.

Case 25: Proliferative.

Arthritis of a violent fulminating type. Patient very sensitive and timid. Improvement has been excellent. Patient has become decidedly more manly.

Case 26: Proliferative.

Very fulminating, generalized arthritis. Nine months treatment. Improved so much, that no further treatment necessary.

Case 27: Hypertrophic.

Very advanced condition. Made practically no progress in improvement. Very introspective.

Case 28: Hypertrophic.

Very fulminating generalized arthritis. Three months treatment. Improved very materially, but stopped treatment before maximum improvement possible was reached.

Case 29: Hypertrophic.

Advanced condition. Very generalized, unable to walk. Treated one and a half years with no improvement.

Case 30: Proliferative.

Bedridden with generalized arthritis. Very neurotic. Now able to do homework, very stable, condition rapidly clearing up.

Case 31: Proliferative.

Advanced condition with tendency to have only one joint involved at a time. Responds readily to sulfur treatment, which he takes when he has trouble.

Case 32: Hypertrophic.

Completely disabled. Now practically cleared up as to symptoms.

Case 33: Mixed.

Violently involved mixed type. Almost completely disabled. Improved markedly when she takes sulfur.

Case 34: Hypertrophic.

Generalized condition. Under sulfur, generalized involvement cleared up, but one knee persisted so that had to stabilize.

Case 35: Proliferative.

Severe generalized condition. Improved as long as treatment kept up, but very nervous and disliked injections very much, which made treatment difficult.

Case 36: Proliferative.

Marked generalized condition. Has practically cleared up under treatment.

Case 37: Mixed.

Severe mixed type. Improved splendidly for ten months, then went to pieces with matrimonial difficulties, and treatment was stopped.

Case 38: Proliferative.

Almost completely disabled. Remarkable response to sulfur treatment.

Case 39: Hypertrophic.

Marked involvement. Being a doctor, would not carry out consistent line of treatment.

Case 40: Mixed.

Marked mixed type. Got no treatment.

Case 41: Hypertrophic.

Well advanced involvement. Afraid would have to give up work as nurse. Reports now that she is markedly improved by sulfur given by her doctor.

Case 42: Mixed.

Marked mixed type. Improves materially when she takes sulfur. Nervous system much involved.

Case 43: Hypertrophic.

Involvement overpowering. Patient very depressed and introspective at first. Improvement spectacular in one month. Relationship to outside world entirely changed.

Case 44: Hypertrophic.

Hardly able to walk when came in. Very depressed. In three months had improved to extent where treatment was dropped and had taken up occupation again. Mental improvement remarkable.

Case 45: Proliferative.

Almost totally disabled. Improved splendidly under new sulfur, but this was discontinued because patient had flare-up of pulmonary tuberculosis.

Case 46: Hypertrophic.

Overwhelmed by condition, which drove her to bed. Died of pneumonia two months after treatment started.

Case 47: Hypertrophic.

Patient came in very introspective, having been prevented from doing work. Improved greatly and has become very stable.

Case 48: Proliferative.

Almost totally disabled. Remarkable improvement with sulphur.

Case 49: Proliferative.

Totally disabled. Has made definite strides in improvement, although definitely not well after several months.

Case 50: Hypertrophic.

Rapidly becoming disabled. Pain in spine almost intolerable. Definite improvement with sulfur. Now going to England on six months trip.

Case 51: Proliferative.

Was completely disabled. Has improved so much that patient is worried that sulfur treatment may be stopped.

Case 52: Proliferative.

Severe generalized type of involvement. Improved when under treatment, but this has been sporadic.

Case 53: Hypertrophic.

Had to give up work as nurse because of condition. With sulfur treatment was able to return to active duty in a few months.

Case 54: Proliferative.

Bedridden with condition. Under sulfur treatment made such strides that now up and around the house. Developed thrombosis, and treatment was stopped.

Case 55: Hypertrophic.

Stable, analytical person with almost all joints severely involved. Almost totally incapacitated. Improved so much that went away for a holiday.

Case 56: Proliferative.

Totally disabled. Only little residue of arthritis left now.

Case 57: Hypertrophic.

Bovine, two-fisted type of person, definitely conscious of arthritic limitation. Improved to such an extent that has recently returned for more sulfur of own accord.

Case 58: Proliferative.

Rapidly becoming disabled. Very introspective. Little improvement noticed.

Case 59: Proliferative.

Generalized involvement. Quite marked improvement with sulfur treatment, and now patient asks to have new series.

Case 60: Hypertrophic.

Hardy, untemperamental with very severe generalized type. Very refractory in responding to treatment and has only been able to hold own.

Case 61: Hypertrophic.

Generally severe. Polyglandular case type. Treated six months. So relieved at end of that time, patient didn't feel that he wished any more attention. Became very stable and improved position as worker.

Case 62: Hypertrophic.

Phlegmatic, stolid type of person. No improvement.

Case 63: Mixed.

Totally disabled. Treatment has not been consistent and improvement poor.

Case 64: Proliferative.

Totally disabled. Patient got so could come to office for treatment, when she then stopped.

Case 65: Proliferative.

Very severe generalized type. Improved so much under sulfur, that when husband had to move to Tennessee, she considered staying in Virginia unless treatment could be continued.

Case 66: Proliferative.

Almost completely disabled generally. Now able to do a full day's work on the farm.

Case 67: Hypertrophic.

Generalized type which almost entirely cleared up, except for condition in spine which was stabilized. Subsequent death due to cardiac involvement.

Case 68: Proliferative.

Bedridden. Improved under sulfur so much that wishes to take only this treatment.

Case 69: Hypertrophic.

So badly involved generally that had to give up nursing. Under sulfur treatment returned to duty.

Case 70: Proliferative.

Generalized condition of long standing. No treatment so far as the causative background is concerned.

Case 71: Proliferative.

Generalized type. Improved so much under sulfur treatment that she drives 80 miles three times a week for the treatment.

Case 72: Proliferative.

Almost completely disabled. Had to be carried. Drives 100 miles three times a week for the treatment now.

Case 73: Hypertrophic.

Generalized mixed type, involving whole body. Very nervous. Under nine months' treatment able to do work on the farm with only minor complaints.

Case 74: Mixed.

Violent, fulminating type. Almost completely disabled. So improved that she made trip to Arkansas where treatment carried on. Patient continues to improve.

Case 75: Hypertrophic.

Patient almost completely disabled with generalized arthritis, with knees affected worse. Now leads a very active life.

Case 76: Proliferative.

Violent, fulminating type. So improved that she has little faith in any treatment other than sulfur.
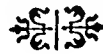
WHEN all the muscles of the eye are paralysed the condition is known as ophthalmoplegia externa and is generally due to a gumma in the floor of the third ventricle.

The brief excerpts in this issue have been taken from "The Essentials of Modern Surgery," edited by R. M. Handfield-Jones and A. E. Porritt (William Wood).

THE SIGNIFICANCE OF THE CYSTINE CONTENT OF FINGER NAILS IN ARTHRITIS

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IN the course of his work on the relation of sulfur and cystine to health and disease, Sullivan[1] developed a highly distinctive test for the amino acid cysteine. Since cysteine, $CH_2SHCHNH_2COOH$, is made from cystine by reduction, the test could be applied readily to cystine,

$$COOHCH(NH_2)CH_2S\text{-}SCH_2CH(NH_2)COOH,$$
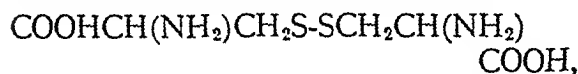
appropriately reduced. Then in 1929, a quantitative procedure for cystine was published.[2]

While applying the Sullivan test in comparison with other tests for cystine, the Folin-Marenzi,[3] the Okuda,[4] all different in procedure, to a long line of materials, foodstuffs, enzymes, tissues, hormones, hair, etc., occasion came to analyze normal finger nails as an example of keratin material long known to be rich in cystine.

As briefly noted by Sullivan and Hess,[5] the analyses by all methods indicated that normal finger nail clippings contain from 11 to 13 per cent cystine. In the analyses was included the finger nail clippings of one arthritic, aged 26, diagnosed by his physician as a case of infectious arthritis and in poor physical condition. As anticipated, on theoretical grounds, his finger nail showed only 8.87 per cent cystine. The finger nail clippings of this case of arthritis were analyzed once a month for six months. At the end of the study the young man, by virtue of diet, rest, etc., was in excellent condition and the cystine content of his finger nails had risen to 11.3 per cent. The improvement in physical condition preceded the marked increase in the cystine content of his finger nails by a month or two.

There the question of finger nail analyses of both normal and arthritics rested until 1932 when the writer was invited to a meeting of a group of physicians interested in arthritis. At these meetings much was said as to the baffling nature of arthritis, the possible rôle of the glands of internal secretion, etc. On request, the writer spoke of the part played by sulfur and sulfur compounds such as cystine, cysteine, and glutathione in vital activities and especially of the findings with the one case of arthritis previously mentioned. As a result of the meeting the writer offered to determine the cystine content of 100 finger nail clippings of well authenticated, long continued cases of arthritis, as free as possible from complications such as gonorrhea.

Accordingly, as detailed by Sullivan and Hess,[6] the finger nail clippings of twenty-six normals and of 103 arthritics were analyzed for cystine. The normals varied from 10.28 to 13.02 per cent with an average of 11.69 per cent cystine. The arthritics varied from 7.20 to 13.11 per cent with an average of 9.77 per cent. The same relative findings between the normal nails and the arthritic nails were obtained with the Okuda method.

Studied statistically, 22 per cent of the arthritics showed below 9 per cent cystine and 57 per cent were below 10 per cent cystine. The lowest normal had 10.28 per cent cystine in his finger nails. Taking this figure as a comparison, 65 per cent of the arthritics were lower with a general average of 9.08 per cent. From the data gathered it was obvious that in the majority of arthritic cases examined, the cystine content of the finger nails was considerably below the normal.

All the normals and all the patients were of the white race, domiciled for some years in the United States and on a good plane of nutrition and vitality. The finger nail clippings of both normal and arthritics were collected in the same way. Before clipping, the nails were cleaned with a nail file or by dry brushing but were not washed with water or soap. As far as arthritis was concerned, it was recognized that the cystine content of the finger nails had no specific diagnostic significance because (a) low cystine nails were found in other conditions as, for example, psoriasis and acute rheumatic heart conditions; (b) arthritis occurs even with a high content of cystine in the finger nails.

The conclusion, however, was drawn from the finger nail work that the low cystine content of the finger nails seemed to imply an intoxication factor which draws on the sulfur complexes and thus diverts the sulfur from its normal channels which would lead to a finger nail containing at least 11 per cent cystine.

The fact that in many cases of arthritis low values for cystine were found in the finger nails suggested that the chemical defense of the body was low, since as will be shown presently, the animal body uses sulfur and sulfur complexes for regulation of metabolism and for defense.

Detoxifying Action of Sulfur and Sulfur Complexes. Among the prominent detoxifying compounds employed by the body in defending itself from injurious material coming from without or formed in the body by microorganisms or cellular activity, are glucuronic acid, an oxidation product of glucose, and the sulfur-containing organic compounds, cystine, cysteine, and complexes thereof such as glutathione. It has been noted by the English school, headed by Hopkins,[7,8] that glutathione, a tripeptide of glutamic acid, cysteine, and glycocoll, is a constant and necessary constituent of tissue cells. The evidence to date seems to be that glutathione plays an important rôle in cellular respiration, oxidation and reduction, and as shown by

various investigators, in the stimulation of enzymotic activity. Glutathione is in fact regarded as the co-enzyme for glyoxalases. Its sulfur is very loosely bound and is readily separated off to aid in detoxication.

It may be emphasized also that the glands of internal secretion in general play a rôle in bodily defense. In this connection it may be noted that Du Vigneaud[9,10] proved that the sulfur of insulin is mainly cystine sulfur and that Sullivan and Smith[11] reported a close parallelism between loosely bound sulfur and the active principles of the posterior pituitary gland. In unpublished work, Sullivan and Hess have found cystine in a large number of enzymes and hormones. Cystine occurs in large amounts in hair, skin, and nails and seems to be of value in protecting the organism, to some degree, against the actinic rays of the sun.

Special sulfur complexes are present in cartilage and in the synovial fluid as well as in the saliva and the mucoids of the gastrointestinal tract.

In so far as direct defense is concerned, it was shown in 1879 by Baumann and Preusse[12] and by Jaffe[13] that if more or less toxic material such as brombenzol is fed to a dog, the entire cysteine molecule is combined with the benzol compound to detoxify it and there appears in the urine a cysteine brombenzol complex known as mercapturic acid.

As is well known, indol, formed by intestinal bacteria from the amino acid tryptophane or formed in suppurations or cellular metabolism, is oxidized, when absorbed, to indoxyl, tied with sulfur and excreted in the urine. Phenols are also to a high degree tied with sulfur and excreted. Potent physiologic bases such as histamine lose their physiologic activity when combined with sulfur, as shown by Pyman.[14]

The important organ of defense is the liver. By means of the organic sulfur, cystine and methionine which reach it, the liver carries on important processes of detoxication by neutralizing toxic intestinal products, the phenolic hydroxy com-

pounds, cholic acid, and traces of HCN, etc. As previously mentioned, the hydroxy compounds are eliminated in the urine as ethereal sulfates, while the cholic acid is fixed by the taurine of the bile, and taurine in turn is a derivative of cysteine. The end products of sulfur metabolism are to a high degree eliminated by the kidneys as inorganic sulfur, ethereal sulfur, and neutral sulfur which contains among other complexes small amounts of cystine and potassium sulfocyanate. Sulfur is also eliminated by the skin, the saliva, and the lungs.

Other examples could be given to show that in the sulfur metabolism the animal body has ready though limited means of defense.

Sulfur Therapy. Knowing that the body uses sulfur compounds to render injurious material innocuous and acting on the theory that injurious material reactive with sulfur was present in the arthritic economy, Sullivan and Hess suggested that six patients with low cystine content of the finger nails be given a sulfur therapy in the form of intravenous and intragluteal injections of colloidal sulfur which was already in the market for use in arthritis. For ages there has been a folklore as to the value of sulfur in rheumatoid conditions and we find reference to it in the writings of Pliny the second.

The average of the finger nail clippings of these six patients before treatment was 8.6 per cent cystine; after ten to twenty injections, mostly intragluteal, it was 10.7 per cent. According to the physician in charge of the clinic, Dr. W. P. Argy, all showed clinical improvement, some markedly so. From these results the conclusion seems established that an analysis of the finger nails is useful in arthritis and gives information as to the effect of sulfur or other therapy. The sulfur injected does not make cystine, as some erroneously interpret our findings. It must act either by combining with injurious material and thus sparing the normal sulfur complexes from being diverted or it must stimulate the general defense mechanism of the body.

Our work with finger nails and with colloidal sulfur has been verified in whole or in part by other investigators. Some of this work may be covered first in relation to finger nail analysis and secondly to a lesser degree since it is somewhat outside the scope of the present paper, in relation to the use of colloidal sulfur in arthritis. Woldenberg,[15] using the Sullivan cystine procedure, found that the finger nail clippings of his arthritic patients ran from 6.5 per cent to 9.8 per cent. After the first course of ten injections of sulfur diasporal the cystine content of the finger nails of the same group ran between 11.6 per cent to approximately 13 per cent. He reports that the patients were free from pain after the fifth or sixth injection and that spasticity of the muscles began to disappear. The effusion in the joint gradually became less and after three or four weeks of treatment it was practically gone. No ill effect was observed when the sulfur was injected slowly. Other practitioners have written to the same effect: that there is improvement in the clinical conditions and return to the normal cystine content of the finger nails.

As regards the lower cystine content of the finger nails in many cases of arthritis found by Sullivan and Hess, it may be said that Salt and Neligan[16] found the average cystine content of normal finger nails was 12.12 per cent while in their cases of rheumatoid arthritis the average cystine content was 7.78 per cent. Of their cases of rheumatoid arthritis 75 per cent showed a cystine content below normal. They found a tendency to low cystine nails in other chronic diseases and regard a lessened nail cystine content as indicative of a lowering of the general health.

Rawls, Gruskin, and Ressa[17] found low cystine nails in 67 per cent of their arthritis cases. When the cystine content of the finger nails was below normal, it was usually increased with sulfur therapy. They conclude that the percentage and degree of clinical improvement was greater in those patients with a subnormal cystine content than in those with a normal content.

Johnson,[18] in a report based on 500 cases of chronic arthritis at Freedman's Hospital, Washington, D. C., says "sulfur is indicated in all chronic forms of arthritis and that the effect of sulfur therapy is continuous and progressive." He continued treatment until the patient was symptom-free or the cystine content of the finger nails returned to normal. In some cases he reports that the patient will be symptom-free long before the cystine content becomes normal while others will complain for a time after this occurs.

Wheeldon,[19] employing total sulfur as a measure of cystine, found that the average cystine value for finger nails of his arthritis cases averaged considerably less than the normal and was increased by colloidal sulfur therapy. Wheeldon and Main[20] concluded that colloidal sulfur has a definite place in the treatment of arthritis.

Senturia[21] used colloidal sulfur injections in sixty unselected cases of arthritis and rheumatoid conditions with improvement in 75 per cent of the series. His opinion is that the sulfur aids in the oxidative processes of cells.

Klauder and Brown[22] made a study of the total sulfur of normal and of diseased and abnormal nails from forty-four patients suffering from eczema, psoriasis, tinea, pyogenic infections, spoon-shaped nails accompanying tuberculosis, dermatitis exfoliativa, congenital defects, etc., and found that the percentage of sulfur was below normal in 77.3 per cent of the nails. They also found low sulfur nails in chronic arthritis, primary pernicious anemia, cachectic stages of carcinoma, pellagra, prolonged fever, and dementia praecox. Since they could increase the sulfur content of the nails without proportional clinical improvement they conclude that the determination of the sulfur content of the nails is of little value in the study of diseased nails though such determinations may be of practical value in the study of some systemic infections and pathologic states.

As regards diseased nails and sulfur determinations, it may be said that other factors play a rôle in the health of the nail and may be involved in addition to the sulfur in the diseased and abnormal nails. We may say also that in some work with two abnormal finger nails as compared with eight normal nails of the same individual we found marked lowering in the cystine content of the abnormal nails and directed the individual to a proper diagnosis, by others, of a local mould infection.

The idea that there is a disturbance of sulfur metabolism in rheumatic conditions was early expressed by Cawadias[23] who reported that this disturbance consists in insufficient thiopexy, in other words that the body of the chronic rheumatic has little power to retain sulfur and consequently there is a sulfuria with a high sulfur to nitrogen ratio. On the other hand, Race[24] did not find any increase in the sulfur excretion and thought that change in the S/N ratio was due to incomplete oxidation.

The Relation of the Finger Nail Analysis to Malnutrition and Poor Circulation. The possibility that the cause of low cystine nails was tied up with a general cachexia, a general lowering of health involving poor nutrition and poor circulation was investigated at my request by Dr. Hess.[25] A large batch of finger nail clippings, five gm. in all from normal individuals, was finely cut and thoroughly mixed, hydrolyzed and analyzed for arginine, histidine, lysine, and cystine. The respective percentages of these amino acid were found to be: arginine 6.60 per cent; histidine 0.46 per cent; lysine 2.61 per cent; cystine 11.98 per cent. Of the arthritic nails of chronic arthritis cases from the Veterans' Hospital, Bronx, New York similarly analyzed, the arginine found was 6.62 per cent, the histidine 0.49 per cent, the lysine 2.63 per cent, and the cystine 9.78 per cent. In other words, the three basic amino acids remained practically constant, in both the normal and the arthritic nail whereas the cystine content of the arthritic nail was 18.4 per cent lower than the normal. This finding was interpreted as indicating that the lowering of

the cystine content in the arthritic nail was not due to poor circulation or malnutrition since in both cases there should be expected a lowering also in the other amino acids.

Relation to Chronicity. To test the possibility that the chronic state and general poor health of the arthritic cases studied by Sullivan and Hess may have brought about the lowering of the cystine content of the finger nails, finger nail clippings were obtained from twenty-eight cases of tuberculosis—patients at the Waverly Hills Sanitarium, Louisville, Kentucky. Three of these patients were slightly subnormal, but the other twenty-five were well within normal levels and the average of the twenty-eight was in normal levels. This finding is in agreement with the findings of Payne and Perlzweig[26] who found practically normal cystine values for the finger nails of a group of syphilitics and for a group of tuberculous patients regardless of the nutritional state of the patient. Similarly the finger nail clippings of five cases of marked cystinuria were found to be within normal levels by Sullivan and Hess[27] and by Lewis and Frayser.[28] So the loss of cystine through the kidneys did not affect the cystine content of the cystine-rich tissues.

From the comparative results with tubercular patients and cystinurics, the normal content of arginine, histidine, and lysine in the arthritic nail and the lowered cystine content of many of the individual cases and the lowered cystine of the arthritis nails analyzed in bulk, it would seem: (a) that in chronic arthritis there occurs to a large degree a special disturbance in the sulfur metabolism, a disturbance that may occur in other pathologic conditions; (b) that in trying to offset the injurious agency or abnormal metabolism the inner demand for sulfur is met to the detriment of the outer demand as represented by the finger nails and possibly by the cartilages; (c) as early suggested by Lewis,[29] the inner demands are of greater importance to the body than the outer demand, hair, nails, etc. Thus we may consider that the demands of the glands of internal secretion and the formation of particular hormones and of enzymes, etc., are undoubtedly of far more importance than the hair or finger nails, etc.

With the increased inner demand the outer tissue suffer, and this connotation, the idea that low cystine nails indicate a lowered vital capacity, a weakened physical bank account, a lessened resistance to attack, is one of the great significances of the cystine content of the finger nails. On poor diets, low in protein and in cystine (diets which may have other deficiencies than cystine) loss of hair or poor growth thereof may occur in animals, as shown by McCollum et al.,[30] Hartwell,[31] and Lightbody and Lewis.[32] Secondly, the analyses of the finger nails for cystine give findings of prognostic value in many cases, for if the cystine is raised from low to relatively normal it indicates a return towards normality which might persist if foci of infection, observable and hidden, could be eradicated. At the very least it indicates a capacity for recovery. Both of these concepts are of interest to the medical world and to the practitioner in particular.

SUMMARY

1. Finger nail analysis may contribute to the prognosis and the study of the effect of various treatments since with improvement in clinical condition there is a tendency for the cystine content of the finger nails when low in cystine to return to normal.

2. Arthritis may occur with high or low cystine nails.

3. Other diseases may show low cystine nails.

4. The cystine content of the finger nails in arthritis has no specific diagnostic value as far as arthritis is concerned.

5. In the sulfur metabolism the animal body has a ready though limited defense against injurious agencies, phenol, indol, cyanides, and possibly some amines.

6. The principal significance of the cystine content of the finger nails is that

low cystine nails may indicate a weakened physical bank account and a lessened resistance to injurious agencies.

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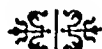
SKIN GRAFTING IN SEVERE BURNS*

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AS a result of a severe burn the essential lesion as a rule is surface loss. The demand is the replacement of the missing epithelial surface.

Previously[1] I have stated that I believe the following points to be especially important in the handling of a severe burn: (1) During the first day or so the systemic changes assume a position of greater importance than the local injury. (2) In the care of the local lesion the use of fundamental principles of cleanliness and good drainage, in contradistinction to the use of this and that preparation or technique which ignores these principles, represents sound treatment. (Early tanning of the local lesion with an appropriate solution I believe is in conformity with these principles.) (3) Insistence on the necessity of early resurfacing of the resultant granulating surface should be stressed because of the marked decrease in the period of convalescence with its economic potentialities and the extent to which functional incapacitation from contracture or cosmetic blemishes can be forefended. (4) When the time for skin grafting is at hand, dependence upon fundamental principles and methods, in contradistinction to the use of unusual types of grafts with or without a "far-fetched" method of placement, puncturing or dressing, usually will tend toward real success.

My experience to date (November 15, 1938) with skin grafts used for the purpose of alleviating the damage caused by a severe burn is as follows: 203 grafts of thin or intermediate thickness applied in 153 operations on 131 individuals. Sixty of these were applied to a granulating surface and 143 to a clean raw surface. Also, 278 thick skin grafts in 181 operations have been applied to 143 individuals.

The state of healing of the injury, the location and the functional demands all enter into the question of the selection of therapeutic method. The types of individuals encountered by the reconstruction surgeon fall largely into two groups. First, the unhealed lesion which will present or does present a large granulating surface. The destruction may be surface deep or deeper, in which case tendons, bones and joints may be involved. The constructive procedure in this group of cases varies according to whether it seems wiser temporarily to alleviate the damage done or whether it seems better to attempt permanent reconstruction.

A. UNHEALED LESIONS

Roughly, when only skin or subepithelial soft structures have been destroyed, leaving a clean granulating surface, the indication is to resurface with a sheet of thin type of skin graft which under proper conditions will practically always "take" on a granulating surface. (Fig. 1.) The exception to this statement is on such surfaces as the face and neck where the cosmetic appearance of the thin skin graft is so deficient that often it is wiser to allow the surface to heal by secondary intention so that eventually the scar can be excised and a thick graft applied to a clean raw surface. When the destruction is deeper than the subepithelial tissues, especially about the palm of the hand, the anterior leg or the sole of the foot, and if bone or possibly tendon has been involved and destroyed, the indications demand not only skin re-

[1] PADGETT, E. C. Care of the severely burned with special reference to skin grafting. *Arch. Surg.*, 35:64–84, 1937.

placement but a subepithelial fat replacement both to give added protection and possibly to aid in eliminating a contoural

FIG. 1. In a lesion such as this, if at first the skin is tanned with a tanning solution, and, as soon as a line of demarcation between the dead and the live tissue has formed, wet dressings alternated with tub baths are started at the third week, by the middle or end of the fourth week all of the dead tissue will have separated, leaving a clean, granulating base. The indications then are resurfacing of the granulating area with thin skin. The patient should be covered with skin by the end of the sixth week if the burn has not been so severe that constitutional symptoms prevent early resurfacing. In most cases they will not. A, large granulating wound ten days after beginning the wet dressings and occasional tub immersions. B, one year later. Extension and flexion were normal.

defect. In such situations a pedunculated skin flap of one type or another may have advantages over the skin graft per se.

Relation of Area and Depth to Contractural Deformity. The early recognition of not only the depth of epithelial destruction but the area of complete epithelial loss is an essential point that needs to be grasped by the surgeon if he is to develop a practical successful method of repair. In

cases of burns of a degree that destroy only a portion of the epithelial "pegs" within a period of from two to three weeks, reëpithelization will occur from below upward and skin grafting seldom will be necessary. When all layers of the epithelium have been destroyed, a wound tends to close by two methods: (1) by fibrosis and contraction of the granulating base, and (2) by a slow scarred epithelization progressing centrally from the edges. The anatomy of the part very largely determines the tendency for the surface to close by the first or second method. Thus, when the denuded area is over the side of the ribs or in the middle of the thigh, where the bony structures are strong and the soft tissues only moderately yielding, a greater part of the closure of a wound is made by the ingrowth of scarred epithelium which, according to the natural rapidity of epithelial growth grows in from the circumference. On the other hand, when the destruction of soft tissues is located in front or back of a joint which can be restricted in its normal radius of movement, the greater part of a wound closes by fibrosis, depending somewhat on whether the limiting scar is within or without the angle of movement. The larger the original surface, the greater is the tendency to contracture and limitation of flexion and extension. In some instances an additional factor is added by the density and contractile pull of an innate tendency to the formation of a keloidal scar.

Preparation for Resurfacing of a Granulating Surface. By the end of the third week or the early part of the fourth week, when it is deemed that a well-developed limiting wall of the granulation tissue has formed, the local burned area should be wrapped within a wet thick gauze roll. This dressing should be applied twice daily and kept continuously wet. Early during this period, but not before, while the wound is being dressed, without anesthesia gross dead tissue sometimes is cut away with scissors or a knife. When some difficulty or pain is experienced in removing the dress-

FIG. 2. A, burn, two years after accident. Patient could extend his leg only as far as shown here, and there was a certain amount of subluxation of the tibia on the femur. The leg was cleaned up with wet dressings. Thin skin grafts were placed upon the granulating areas which formed a cuff about the lower leg. B, thick skin grafts were placed in the popliteal space. A Steinmann pin was placed above the os calcis and 20 pounds of weight were attached to the leg. The hamstring muscles were lengthened, but it took the greater part of a month to get the leg straight, as the posterior part of the joint capsule was markedly contracted and the tibia was subluxed partially on the femur. C, six months later, after the application of a full thickness skin graft to the popliteal region and a thin graft on the lower leg. The granulating area showed a tendency for the next eight or nine months to break down here and there. D, two years after the grafting. Patient had perfect function. The scar tissue base below the granulating areas had thinned out. Good subcutaneous tissue had developed and there was no ulceration. The leg had been pulled out so that no shortening of the Achilles tendon occurred, and there was complete power of extension and flexion.

ing, if the patient's condition permits, the patient should be placed in a tub bath for fifteen to twenty minutes until the dress-

repetition of the dressing twice daily are of importance in shortening the period necessary to give a proper granulating bed.
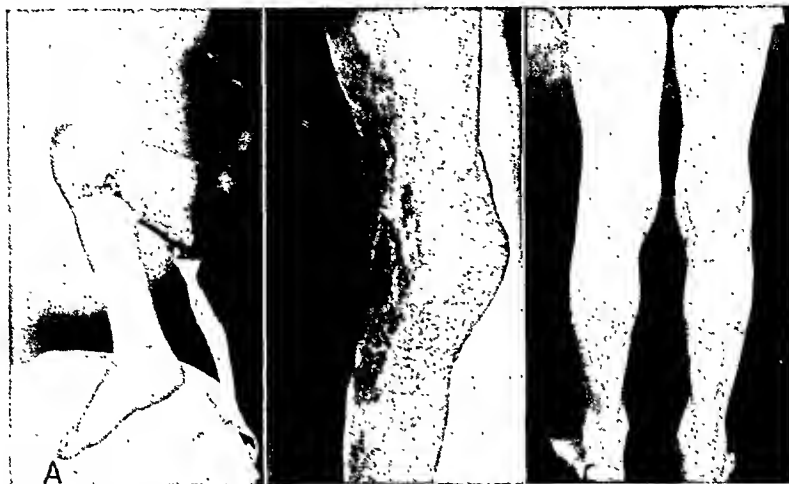
Fig. 3. A, marked cicatricial contracture of the popliteal space of two years' duration. Twice before this cicatrix had been crosscut, but the surgeon failed to recognize that re-epithelization of the raw surface was necessary if the contracture was not to recur. This contracture was crosscut again and a denuded diamond-shaped area of 118 sq. cm. remained. The hamstring muscles were lengthened and a large full thickness skin graft was removed from the abdomen and applied. The boy was placed in a heavy overhead traction after the graft was sewed into place and dressings applied. He had a partial subluxation of the tibia on the femur which was pulled out. B, amount of correction present after six months. C, result obtained about eighteen months later. At the present time the boy is 20 years old and has perfect function. The operation was done when he was 12.

ings fall off more or less spontaneously. Too long a period of immersion will be found to be weakening in some instances. If the patient shows considerable constitutional reaction, immersion may not be advisable. Immediately after immersion a wet gauze roll should be wrapped about the denuded area.

For the purpose of saturating the wet dressings, the particular solution used, provided it is not toxic, should not be considered of great importance. Usually I have used a hypertonic solution of saline, but boric acid, magnesium sulfate, hexylresorcinol and various chlorine solutions have also been used. The advantages of wet dressings are promotion of drainage, maceration at the line of demarcation, mechanical aid to the separation of slough and possibly some mechanical stimulus to the formation of a proper bed of granulation tissue. Moreover, the cleanliness of the method and the

Factors Promoting Epidermization. Besides the general condition of the patient, the most important aid to early epidermization from the circumference of the wound is cleanliness. In the consideration of the general condition of the patient, the factor of a relative secondary anemia will be found to be important both as to the rapidity of epidermization and as to an influence in obtaining a proper granulation bed on which a graft would "take." When the granulations are exuberant, a rather firm, tight bandage will aid in getting a firmer base. When evidence of anemia is present, a blood transfusion should be given.

Grafting of Thin Skin on a Granulating Surface. The appearance of the granulating surface should be used as the index to the time of grafting. The proper appearance is present when the surface is free from evidence of grayish slough or any

gross pus and the granulation base is firm but not too exuberant or watery and is cherry red. Anemic persons do not present

slip, either stitches or a splint of some type or both should be used so that fixation is definite.

FIG. 4. A, anterior view of cicatricial contracture due to burn. B, anterior view of a patient after correction by crosscutting the contracture, hyperextending the arm and laying in a large thick skin graft to cover the denuded area. C, posterior view before operation. D, posterior view three weeks after operation. A plaster cast was applied to hold the arm in hyperextension immediately after operation.

granulation surfaces of the proper texture or color. Whenever grafting is attempted without this criteria being fulfilled, at least a part and usually most of the graft will fail to "take." On the other hand, when they are present in practically 100 per cent of the cases, at least 90 per cent or more of the graft will "take."

After laying the graft on the granulating surface, the same type of thick roller gauze dressing should be applied as previous to grafting. This dressing is not changed for four or five days, and during this time it is kept saturated with saline solution or a saturated solution of boric acid. When the graft is located so that articular or muscular movement will probably cause it to

When the granulation base is relatively new, a large thin graft will show a greater tendency to "take" well if the granulation tissue is not interfered with, but when sufficient fibrosis had occurred to give a firm scar base the chances of a complete "take" with a thin graft after the granulation and a part of the yellow scar base are sliced off, are not decreased; often some of the contracture is relieved, and better functional and cosmetic results are thereby obtained.

In several instances in which the patient is seen for the first time several months after the original injury and healed contractures have formed but part of the surface remains unhealed (Fig. 2), it often

will be possible not only to cover the granulating area with a thin graft but to cross-cut the contracture and largely cor-

large in about 20 per cent of the operative attempts—the variation depending principally upon the anatomy of the region. The
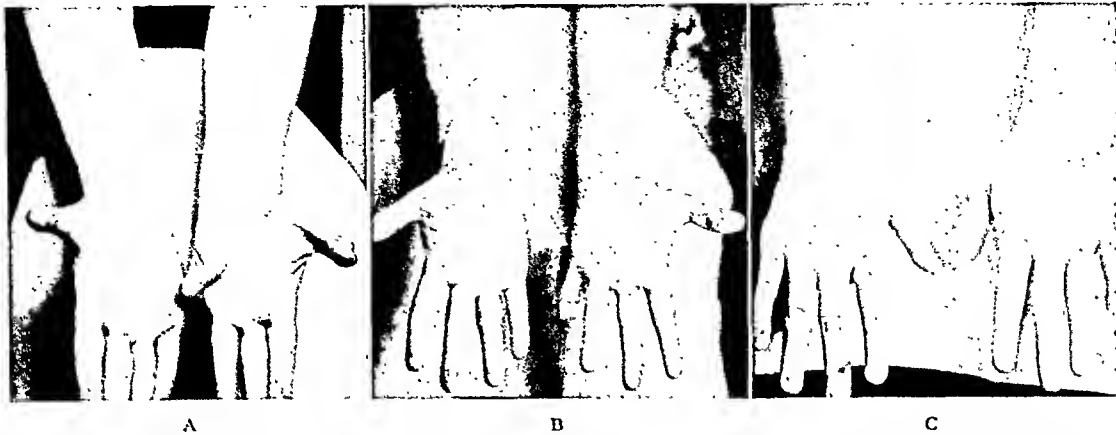
FIG. 5. A, scar contracture over the dorsum of the right thumb and the wrist which had practically subluxated the thumb. The left thumb and the left little finger showed flexor contractures. A large thick skin graft was placed over the dorsum of the thumb and the ventral surface of the wrist, which relieved the contracture and corrected the thumb subluxation. B, ventral view of the hands after correction. C, dorsal view after correction.

rect the contractural deformity. In cases in which the contracture is graver, deformity is not always prevented by the application of a thin graft and the cosmetic result on such areas as the neck and face is often definitely unsatisfactory. Moreover, on such regions as the palm of the hand, the front of the leg and the bottom of the foot the amount of protection which a thin graft offers to the underlying tissues is not sufficient.

B. HEALED LESIONS

In the second group of cases either the preliminary resurfacing has contracted sufficiently to allow a residual contractural deformity or the wound has been intentionally allowed to heal by secondary intention with the idea of relieving the contractural deformity at a later date. Then one has the advantage of a clean field and can use a considerably thicker skin graft which will have less of a tendency to contract and will give a much better cosmetic appearance and better protection.

Formerly when a full thickness skin graft was used to correct a healed defect, unfortunately one had to consider the possibility of a partial or even a complete failure to obtain a good "take" by and

causes of loss were some infection, lack of adequate pressure and in a few instances too much pressure, the formation of a blood clot or improper splinting.

Final Contracture of the Grafted Area. Provided a good "take" of a thick graft occurs the most important influence on functional result is the final amount of contracture of the grafted area.

The properties of skin grafts are very much dependent upon their relative thickness or thinness. Outside of certain anatomic factors (which may form a base which prevents contracture) skin grafts tend to contract in direct proportion to their thinness. When placed on a freshly made raw surface with a movable base, a thin graft or one of intermediate thickness may contract as much as 60 per cent. However, if such a graft is laid upon a freshly denuded scar base or on derma, periosteum or bare bone, or on areas surrounded by tense skin or scar, the subsequent contraction will be considerably less. Besides the factor of ultimate contraction, the final appearance tends away from that of normal skin more or less proportionate to the relative thinness of the graft. The thick skin graft most nearly approaches that of normal skin in appearance.

Dressings for Grafts on Fresh Raw Surfaces. As a rule, a graft applied to a clean raw surface should be fixed by stitches, popliteal space (Fig. 3), or the elbow, full movement of the extremity is the first consideration. In the axilla it will be found
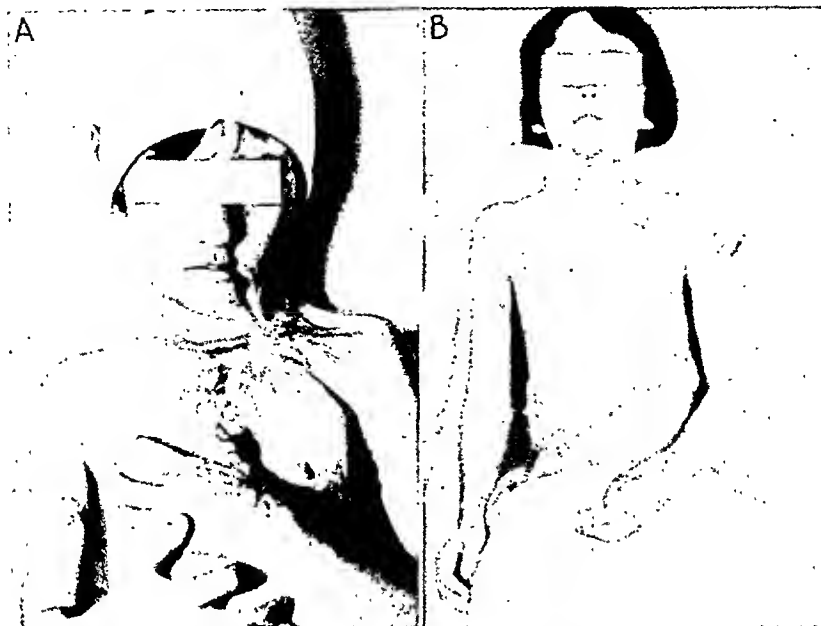
FIG. 6. A, marked contracture drawing the chin down to the clavicular region on the left side. Thumb was practically hyperextended due to scar. A large thick skin graft was placed on the neck and one on the dorsal surface of the thumb. B, three weeks after the application of the graft. The grafted areas are slightly discolored due to picric acid, which happened to be used as an antiseptic agent. There was considerable smoothing out of the graft after the photograph was taken. All functional disability was corrected. The suture line crosswise of the abdomen shows the extent of the full thickness skin removal.

whether or not a thin or thick graft is used. A dressing of gauze treated with 5 per cent bismuth tribromphenate in petrolatum is laid on the graft and then a moderately thin layer of gauze is applied. Finally, a damp marine sponge either compressed by a bandage or stitches or both over the graft is applied.

When the danger of movement is an eminent factor, some type of fixation by splinting is added. Externally, when the anatomy of the location is such that an outlay wax stent gives better chances of the proper amount of pressure and tension on the graft, the tissue to be grafted is stitched about a wax form or a marine sponge form. Internally, within the mouth, as a rule a wax stent is used.

When one wishes to correct a contracture about such a region as the axilla, the that a good "take" with a thick skin graft is somewhat difficult to obtain because of the likelihood of not obtaining uniform pressure. (Fig. 4.) One does not encounter this difficulty about the elbow or the popliteal space. An axillary contracture can be corrected by means of a thin skin graft but two operations may be necessary. As this graft is the most certain to grow and the postoperative period of dressing is short, after making use of any material available for a switch pedicled flap, the application of a graft of intermediate thickness as a rule is the method of choice. The same applies to perineal contractures. About the elbow and about the popliteal space, the groin or the back of the hand (Fig. 5) the thicker type of graft is preferable. For cicatricial contractures of the palm of the hand and the flexor surfaces

of the fingers the thick skin graft offers a better functional result. If one uses a thin graft in these areas it will be found that

when applied over the orbicularis oris muscle for an ectropion of the upper or the lower lip.

FIG. 7. A, keloidal scar of both sides of the cheeks due to a burn. This was corrected by excision of the entire scar and the application of a thick skin graft. B, three years later. The color and texture of the full thickness skin graft very nearly approach that of normal.

the final contracture is considerable, that the appearance is not very good and in the case of the palm of the hand and the ventral surface of the fingers, the protection may not be adequate.

On the anterior portion of the neck, a thin skin graft, although almost certain to "take," usually contracts from 50 to 70 per cent—too greatly to correct the contracture and the appearance usually is not satisfactory. When a good "take" of a thin skin graft occurs, the contracture is corrected in from one to two operations and the cosmetic result is good. (Fig. 6.) The swallowing movement usually will cause some loss of graft over the thyroid cartilage no matter what type of dressing is used with the idea of preventing it. In later cases an attempt has always been made to leave a raw area over this region.

On the sides of the cheek and over the mandible a thick skin graft should be given the preference because the graft more nearly approximates the normal skin in appearance. (Figs. 7 and 8.) Some of our most brilliant results have been obtained with large thick skin grafts to the face. Although the appearance of the graft is somewhat whiter than normal skin, a thick graft will give a fairly satisfactory result

When a thick skin graft is used on the neck and chin, about the mouth and over the cheek, in some of the cases a secondary operation is necessary after a period of several months for the purpose of excising the rather heavy scar which tends to form at the juncture of the skin graft with the surrounding normal skin. Moreover, in advent of obtaining a good "take" of a thick graft on the face, the possibility has to be considered of having the graft too shiny or in brunettes of presenting a discoloration from pigmentation. Although there is a tendency for the thick skin graft to have a slightly shiny appearance, the grafts that "take" well without superficial exfoliation eventually show almost the normal texture of the skin of the region from which the graft was removed. The grafts in which some superficial exfoliation occurs have more of a tendency to pigmentary changes. In pronounced brunettes, pigmentation sometimes occurs after a perfect "take."

On the sides of the neck, over the sternocleidomastoid muscle and the posterior portion of the neck a graft of intermediate thickness will be found to give an acceptable result functionally and cosmetically.

When a muscle was near the surface, as about the eyelids, about the lips or over the sternocleidomastoid muscles on the side be cut of any size in one sheet, from any part of the body and of any thickness desired.

Fig. 8. A, severe burn of chin which pulled lower lip into a position of ectropion. Considerable scarring of upper lip and sides of cheeks does not show very clearly in the photograph. B, scars were completely excised and a full thickness skin graft was applied to the upper lip, the sides of each cheek and beneath the lower lip. A graft of 6 by 2 inches was applied beneath the chin. This does not show in the illustration, but was necessary for complete relaxation. The dots show the extent of the graft. The face has assumed normal appearance and the lips normal position.

of the neck, the results obtained after the application of a thin graft of intermediate thickness are as good or in rare instances even better than after the application of a full thickness graft.

Acceptable eyebrows may be made with a thick skin graft from the scalp. The hair will be found to be somewhat sparse and less plentiful than in a normal eyebrow, but with care in clipping the new eyebrow may be fairly successful.

C. THE CALIBRATED GRAFT*

During the past year we have been able to develop a new graft—the calibrated skin graft—cut by a special machine which in our hands has caused us to drop the use of the so-called "split" graft as cut by the razor or large skin graft knife and the so-called "full thickness" skin graft as cut by the scalpel from such an area as the abdomen or thigh. Basically, the advantage of the calibrated graft is that the graft can

* A more complete paper describing this graft is now in preparation.

Varying Thickness. When the main indication was one of resurfacing a granulating area, we have cut the graft from .010 to .014 of an inch in thickness. When the main indications were those for which a good "take" of a full thickness graft in the past would seem ideal, usually we have cut the grafts from .025 to .028 of an inch in thickness. This applies to the adult. In children a thickness of .016 to .018 of an inch may cut deep enough to remove all subepithelial structures. In women on the inner thigh .020 to .024 of an inch in thickness may do the same. The thick calibrated graft is somewhat thinner than the so-called full thickness graft cut in the usual manner with a scalpel. When the graft is kept at the proper thickness sufficient of the epithelial elements remain in the bed from which the graft is removed so that epithelization is from the base, as after cutting a "split" graft. In other words, the wound does not have to be closed by sutures as after removal of a full thickness skin graft.

Advantages of the Calibrated Graft over the Usual Free Graft. In at least three types of cases the calibrated graft (.010 to .016 of an inch in thickness) has distinct advantages over the so-called thin graft used in the past. First and foremost, it allows one to graft successfully in a type of case occasionally seen which in the past has been hopeless, namely, where a tremendously large denuded surface exists with the remaining skin on the trunk. For example, in a patient with both legs denuded, at the first operation 744 square centimeters of skin were removed from the abdomen and anterior chest. This covered about one-half of the denuded area. At a second operation four weeks later, 781 square centimeters of skin were removed from the abdomen and anterior trunk which completed the resurfacing.

Besides the outstanding advantage just outlined, to a lesser degree such a graft removed in a perfectly uniform sheet has the same advantages for cases in which the denudation has been somewhat less but is still very large. Again, for the routine case in which it has been customary to use thin grafts successfully, the ease, the accuracy and the uniformity of thickness which the method ordinarily provides in our hands recommends it as the preferable one. This applies to cavity grafting also. Moreover, a somewhat thicker graft than the so-called split graft can be used without the danger of not getting a "take" on a granulating surface with the idea of not getting so much contracture and a somewhat better appearance than the "split" graft will give.

The main advantage of a fairly thick calibrated graft (thickness of .018 to .028 of an inch) over the full thickness skin graft appears to be that a "take" is a practical certainty if the other factors are observed, such as proper fixation, tension, hemostasis, pressure and a clean field. In other words, that 20 per cent danger of not getting a proper "take" is practically eliminated. Besides this, the fact that one encounters no blistering or localized areas of necrosis, so that the subsequent texture

and the color are as good as when one gets a perfect "take" with a full thickness graft and better than when one gets a partial "take," is a distinct advantage. Grafts of this thickness also have the ability to stand trauma well. As good a subcutaneous tissue soon develops as that which follows the application of the full thickness skin graft. Finally, the fact that the donor area heals from the base within ten days is of considerable advantage.

The factor of increased certainty of "take" allows one to extend the indications for thick skin grafting in an upward direction. Now one can remove such lesions as large birthmarks and heavy scars from the face and neck without any great feeling of fear. It also allows one to graft difficult areas as the back of the hand and secure a good functional and cosmetic result. In one case of this type due to a severe burn, in which we had previously had a failure with both a full thickness skin graft and later with a split graft, it was possible to get correction with a thick calibrated graft. The certainty of "take" allows one in the correction of marked cicatricial deformity about the larger joints to use a fairly thick calibrated graft which will give a better functional correction as well as a better cosmetic correction if this be a factor.

SUMMARY

1. An experience with 203 thin skin grafts and 278 thick skin grafts used for the purpose of alleviating the damage caused by a severe burn is alluded to briefly.

2. Insistence on early resurfacing of granulating surfaces caused by burns is stressed because of the marked decrease in the period of convalescence and also because of the extent to which the functional incapacitation from contractures and cosmetic blemishes can be alleviated.

3. Stress should be laid upon fundamental principles and methods of skin grafting in contradistinction to the use of unusual types of grafts with or without a "far-fetched" method of placement, punc-

turing or dressing, as we believe these fundamental methods practically always tend to real success.

4. The general principles of resurfacing an unhealed granulating surface can be discussed under the heading of the relationship of area and depth to the amount of contractural deformity; the preparation of the granulating surface for resurfacing, factors which promote reëpithelization and the type of graft preferable.

5. The factors which are responsible for a healed cicatricial contracture should be stressed. The technique of correction of healed contractures must be emphasized. The average amount of final contracture of the grafted area, the chances of a good "take" and the various types of grafts preferable for certain locations influence one in the selection of the type of graft to be used.

6. The use of "calibrated grafts" seems to herald a definite step forward in the art of skin grafting and the final results obtained by their use are considerably better than those obtained previously.

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THE FALL AND RISE OF PLASTIC SURGERY*

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IN the year 1528, Albrecht Durer published in Nuremberg a book called *The Proportion of Human Anatomy*. It is illustrated with sixty cuts and four folding plates of human figures, introducing
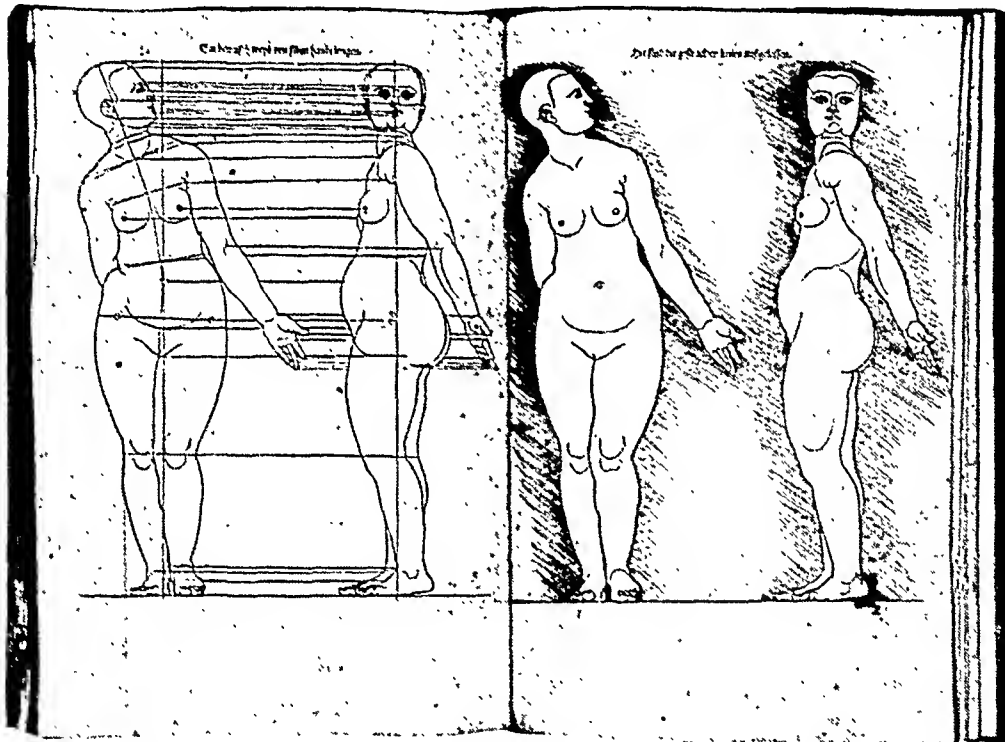
FIG. 1.

Albrecht Durer's "Study of Human Proportions," the first edition published in 1528, contains numerous plates of all types of figures with the measurements necessary for reproduction in proportion. It is a folio and bound in vellum.

the first background shading of anatomic drawings. (Fig. 1.) This innovation opened the way for the more elaborate illustrations, later destined to embellish treatises on the subject of human body reconstruction. Strange, that this earliest printed work dealing with the

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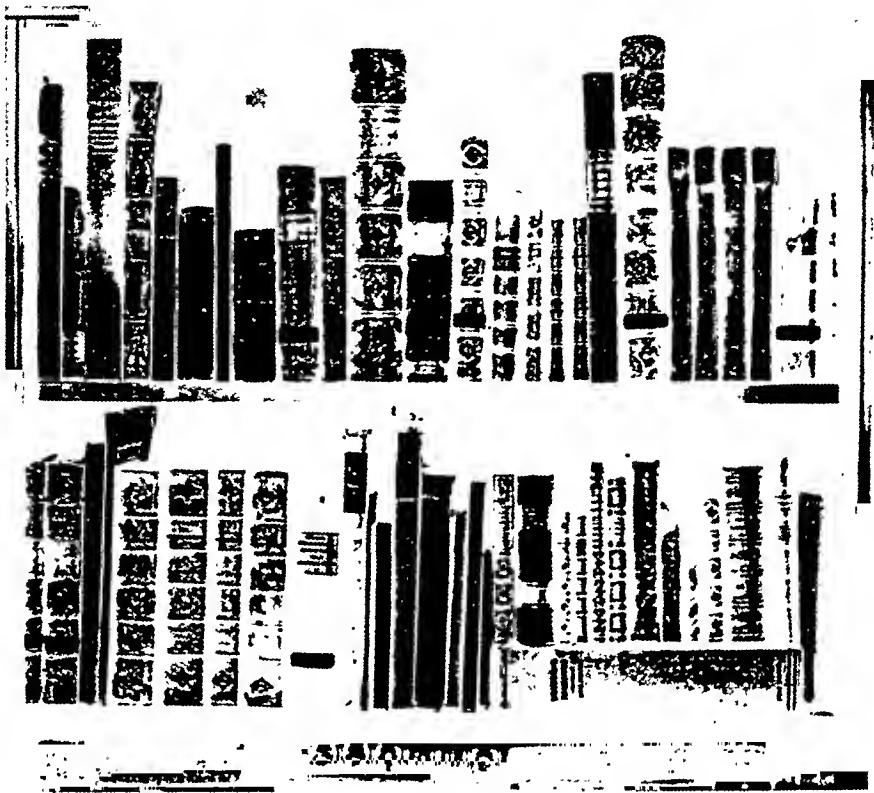
PLATE 1

The Book Story of Plastic Surgery. Upper row, reading left to right: A collection of plastic incunabula containing many important early volumes, beginning with a first edition of Durer (Bücher von Menschlicher Proportion, 1528); Aldine (Celsus, 1528); the first four editions of Taliacotius and Jerome Webster's magnificent treatise in Italian on Taliacotius; Paul of Aegina (Opus de re Medica Nure Primum Integrum Latina, 1542); Giovan B. Porta (De Humana Physiognomia, 1593); Marco Severino (De Recondita Abscessum Natura, 1643. Several chapters on surgery of the mouth and monstrosities); Ambroise Paré's Works (First English Edition, 1634); Sylvester Rattray (Theatrum Sympatheticum Anctum, 1622—famous book on "powder of sympathy"); Francois Thévenin (Des opérations de chirurgie, 1669; early description of harelip operation); Samuel Butler (Hudibras, 1664, in three volumes); Samuel Butler (Hudibras, 1775—first illustrated edition); Fabricii (Aquapendent Chirurgia, 1666; beautiful cuts of surgical instruments and descriptions of plastic procedures); Joh. von Helmont (Opera: Ordus Medicinae, 1667—everything to date on magnetic healing and powder of sympathy); Laurence Heister (Institutiones Chirurgicae, 1749, four volumes; vol. 11 has good description of method of repairing nose and upper lip with folding plate No. 19, showing method and instruments); Dr. Read (Chirurgorum Comes, 1697; page 704 has the famous account of the engrafting of a new nose by Dr. Griffinous in London in 1610); George Franck (Satyrae Medacae, 1722, contains important "De Restitutione in integram").

Lower Row, reading left to right: Alberto von Haller (Bibliotheca Chirurgica, 2 volumes, 1774—early source book on plastic work); Angelo Nannoni (Trattato Chirurgico, 1770—description of a case in which Taliacotius is quoted; first edition was in 1764, but this is considered the better edition); Guiseppe Sonsis (Memoria Chirurgica, 1793—deals exhaustively with harelips); J. S. Lavater (Essays on Physiognomy, 1904, 4 volumes Imp. octavo); J. F. Dieffenbach (Chirurgische Erfahrungen, 1829-1834—three volumes bound together); Carl Graefe (Rhinoplastik, 1818); Paolo Fabrizi (Rhinaplastia, 1841—contains an interesting history of plastic surgery in Italy from the Brancas to Taliacotius); Ledoyen (Essai de Collaplastic, 1855—early book on cosmetics); Leroy Crummer (Catalog of his library of medical incunabula, 1926—one of the most famous of the day); Lewis Pilcher (Ex Libris Antiq., 1918—another famous old medical book catalog).

elements of plastic surgery should have been written by a man who was not a physician!

A first original edition of this important work lies before me and I am impressed by its excellent state of preservation, made possible by the quality of the paper used at that time. Paper was then made from clean, fresh flax from the fields, rather than from the linen scrap and pulp mixtures of today. The original manuscript, containing 283 pages, is to be found in Dresden. While this book of Durer's contains no mention of plastic surgery, practically all essays and studies of the proportions of the human figure have been founded on this slim, vellum-clad volume, whose illustrations include the lean and the fat, the young and the old. Durer is said to have had great difficulty in getting nude female models, but he seems to have discovered their exact proportions for his work (Pilcher). It is said that his wife was a typical Xantippe, which makes me wonder whether some of the sketches, the subjects of which are not particularly beautiful, might be of her.

Three thousand years before Durer, other medical artists illustrated a series of papyri in color, with hieroglyphics, depicting among other things certain plastic procedures. George Ebers unearthed some of these papyri in 1872, during his excavations in Thebes, thus establishing the cradle of plastic surgery. In the Smith facsimile, the Egyptian papyrus in color is on the left hand page and the translation on the opposite page. The repair of mutilated faces, noses, jaws, and ears is mentioned, and, since physicians then were allowed to treat only one ailment, we can say that plastic surgery, as a specialty, was born. Incidentally, the birth place of adhesive tape was also established there, since well-defined references to linen bandages, spread with glue, are mentioned.

According to Garrison, information about Egyptian medicine traveled to Arabia, and then, by the itinerant physician of that country, on to India. The great wars during the five centuries before Christ brought back added surgical knowledge from India to Persia. Then the cycle of advance in plastic surgery waned, as has always been the case, when wars have ceased to contribute patients. Until the sixteenth century but a half dozen names stand out with prominence in the specialty.

Garrison tells us that Celsus (25 B.C.) wrote, "not as a physician, but as a private gent," and that in 1528 the Aldine Press gave to the world a fat little volume of Celsus' work. (Fig. 2.) It was an octavo

volume, the title page and the last leaf bearing the imprint of the
Aldus anchor. It was entitled *Medicinal Lebri VIII* and was edited
by Quintus Serverinus. Book VII of this vellum-bound (contem-
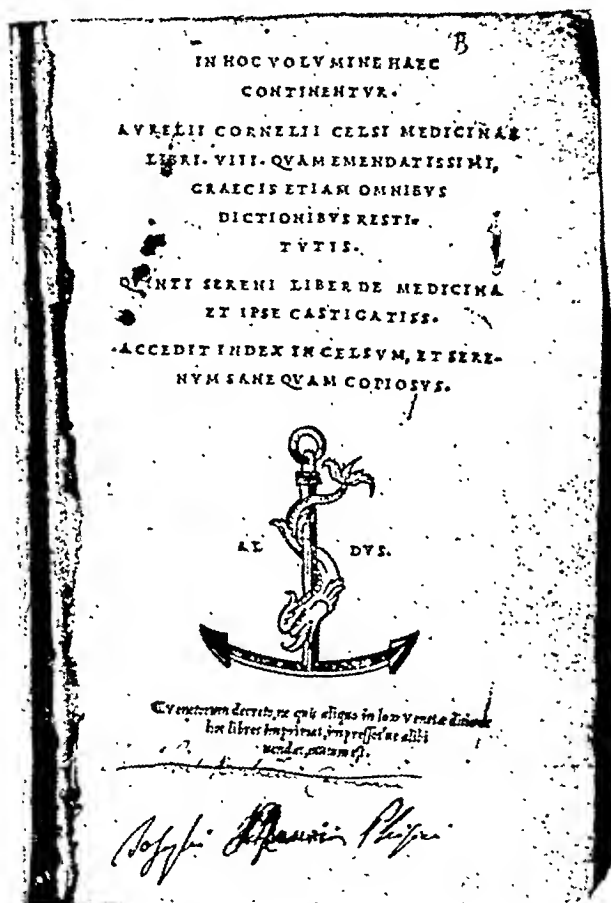
FIG. 2.

Celsus wrote in 24 B.C., but the first printed account of his
work was published by the Aldine Press in 1528. Books
from this printer always bore the Aldus anchor on the
title and end pages. The title page of this octavo volume,
bound in parchment-covered boards with gold lettering,
is here shown.

porary) effort contains two chapters (IX and XXV) which deal with
such wonders as free grafts and eyelid surgery for ectropion, but
questions the possibility of the repair of lips and noses with skin
flaps from adjacent areas. It was Celsus who first assigned a birthdate
to these procedures for future generations. Books from the Aldine
Press, with their filigranes and beautiful majuscules, are worthy

examples of the perfection of the printers' guild of the sixteenth century.

About 200 years after Celsus (160 A.D.), Galen stated, that from
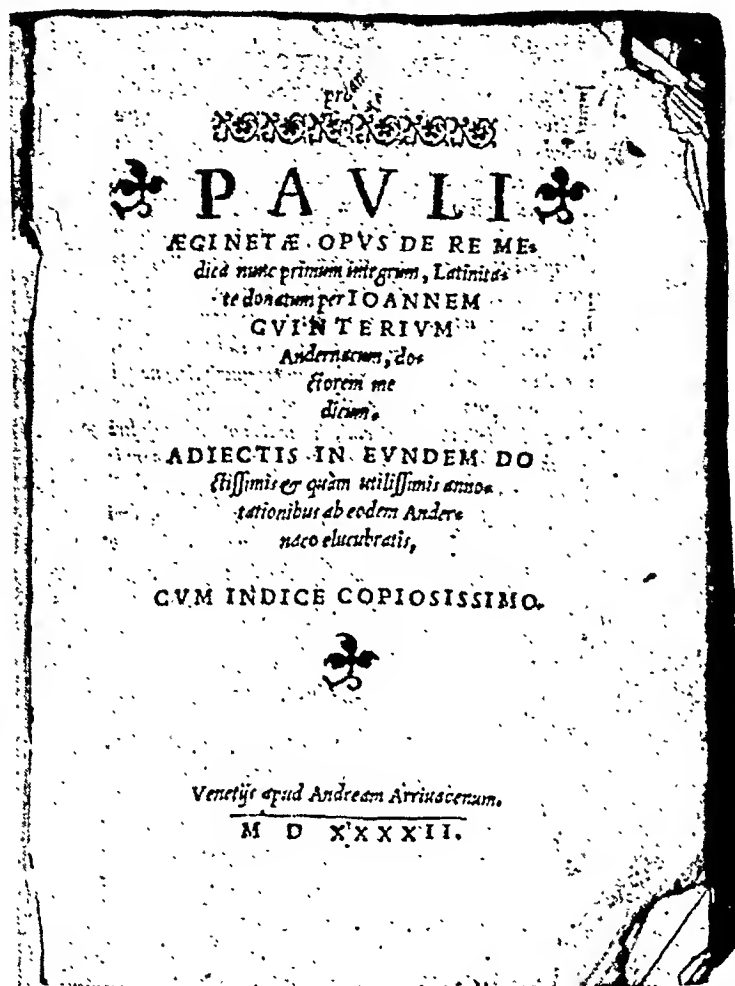
FIG. 3.

Paul of Aegina wrote in 630 A.D. and had his first appearance in print in the sixteenth century. This title page is from the 1542 edition of this work, published in Venice. It is a thick little volume without cuts and in Med. octavo size, bound in parchment.

his investigations and research, he was convinced that the Egyptians possessed a great deal more knowledge of plastic technique than they had allowed to leak out.

One of the fascinations of old-book collecting is the arrival of a volume from abroad, ordered months before, when a feeling of oppulence was in the ascendancy. My introduction to Paul of Aegina was disappointing (Fig. 3): when the package from Italy was

unwrapped, the book covers were so worn as to make me despair of the condition of the contents. However, they turned out to be in remarkably good shape, and this mitigated my disappointment in being able to purchase only the 1542 edition instead of the first edition of 1528, issued by the Aldine Press. The manuscript itself dates back to 630 A.D.

Paul of Aegina was a good military surgeon who had followed Galen's technique, and incidentally, introduced an operation for the removal of hypertrophied breasts in men. Very likely he had been stimulated by the Amazonian maidens' sacrifices to their arms. How very different the story of the Amazons might have read today had mastopexy then been in vogue! Indeed, how much of the world's history would have been changed, had plastic surgery always advanced in proportion to the other surgical specialties. When I tried to place his volume on my bookshelves of plastic incunabula (Plate 1) in chronological order, I was surprised to find that nothing else of importance had been written to survive the following 500 years.

Then a Milanese, la Branchi, wrote of having heard about a severed nose, sutured so successfully that it grew back in place. With the feeling of the time, he hastened to write, stating that the spirit controlled the body, and once a part of the body was severed, its return was impossible. Already the laity and the church were beginning to realize the antagonisms of professional jealousy. Guy de Chauliac (1363), a barber-surgeon of renown, stated that it was difficult enough to sew back a nose, partially severed, let alone a completely detached proboscis.

One of the Branceas, a Sicilian surgeon (1442), reported in manuscript form, (Vol. 1, *Anoli del Morde*, now in the Dominican Library, Palermo) that he had successfully reconstructed entire noses and in consequence was assailed by his colleagues for his report. Benedictus, a contemporary, stated that the noses were not so good in winter and were likely to pull off, while Fallopius, of tubal fame, thought it was better to wear a mutilated nose than to go through a year of surgery to attain a new one. Following the example of the Egyptians, the Branceas then withheld their developments in the plastic art as a family secret for over a hundred years.

With the revival of letters, along in the sixteenth century, the publication of a book on surgery aroused more than ordinary interest. Someone was so bold as to bring out a good sized, vellum-clad vol-

ume, adorned with a handsome, copperplate title page, showing a license by the Venetian authorities on the following page. Its illustrations, twenty-two woodcuts, were related to a subject supposedly disposed of as impractical. The book was by Gaspar Taliacotius and dealt, among other things, with the restoration of missing facial parts. Here, at last, was the pinnacle of published knowledge of the art, interpreted for those who were interested! The ripples made in the pond of public opinion by its publication were of such magnitude as to stir up a scholastic controversy which raged throughout Europe for the next three hundred years.

Gaspar Taliacotius (Tagligcozzi, Taliacott, Tagliacozza, etc. The spelling of the name is so varied that it has been described as a nickname, signifying to "cut with care") saw his book published two years before his death (1599). The title was *De Curtorum Chirurgia per Insitionem*. In the sixteenth century the art of restoring lost parts was called "Chirurgia Curtorum." Henceforth one said: "curta reficere," "instaurare," or "restaurare." The frequently used words: "prosthesis" and "decoratio" had a more general significance, since they referred simultaneously to the application of artificial mechanisms for the restoration of missing limbs or to various cosmetics.

There are only four editions of Taliacotius' book (Fig. 4), the first of which appeared in Venice in 1597, from the press of Gaspar Bindonus, Jr. The name of the publisher at that time was found on the title page and the editions are commonly known by this point. My "Bindonus" copy is a vellum-clad folio with tie-strings and bears the Perry arms on the cover and the Huth bookplate. We have no way of knowing the size of this edition. Presumably it was not large, for it was issued within 150 years of the Gutenberg Calendar (1460), ordinarily accepted as one of the first printed medical books. It is a perfectly preserved copy and is annotated occasionally by hand, proving at least, that it was sufficiently interesting at the time to be read through.

The demand for the edition was evidently strong enough to warrant the publication in the same year (1597) of an inferior reprint, done in Venice by Robert Meiettus. The title page differs from that of the "Bindonus" edition, and the license to publish, from the Venetian authorities, is missing. The wood icons are evidently drawn by another artist, since the sketches vary somewhat, and the publisher has taken advantage of the two pages of "corrigends" in the "Bindonus" and connated his text. My copy has an additional
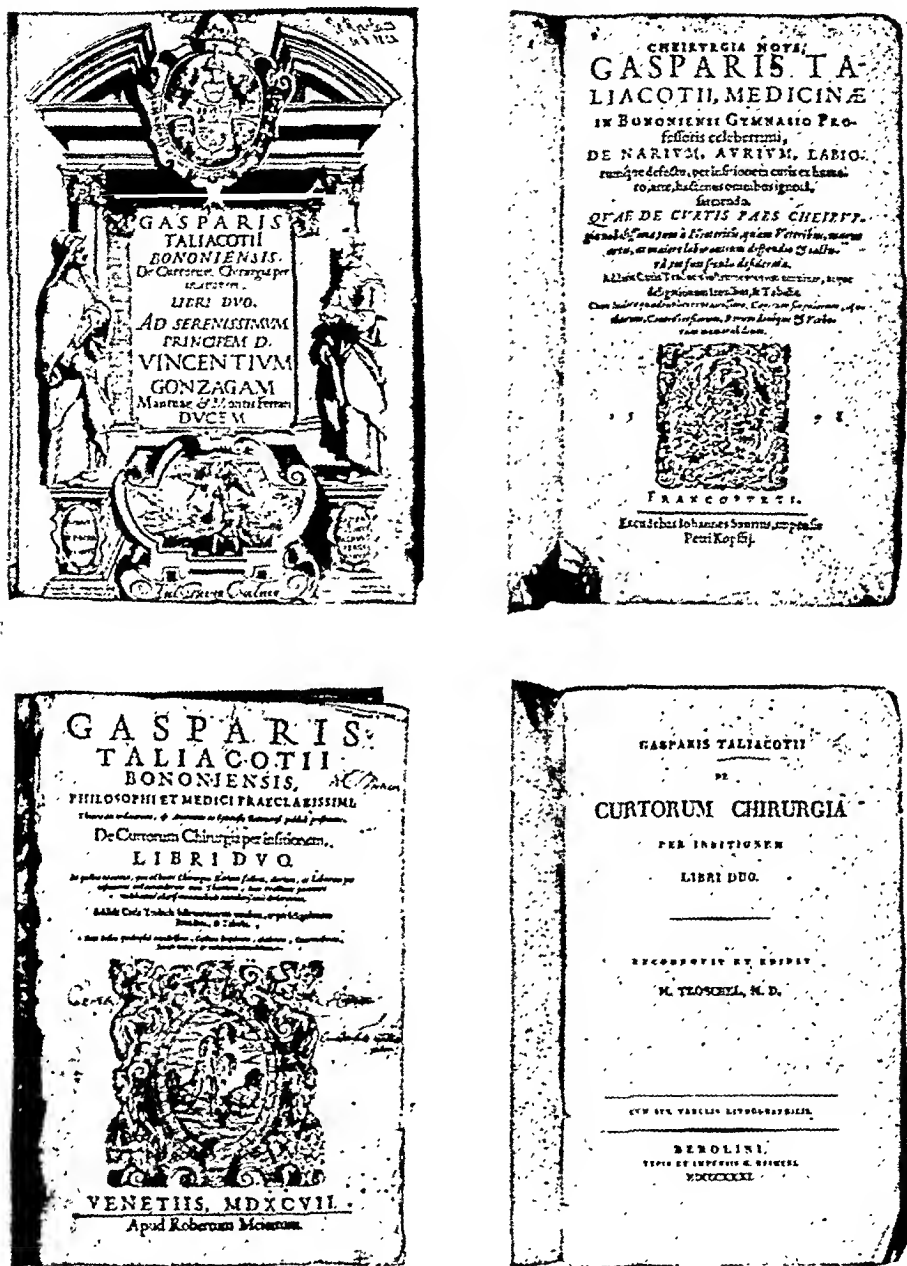
FIG. 4.

Title pages of the first four editions of Taliacotius (identified by publishers). De Curtorum Chirurgia. Upper left—Bindonus, 1597. Lower left—Meiettus, 1597. Upper right—Kopffins, 1598. Lower right—Reimeri, 1831. The Bindonus and Meiettus are folios, while the Kopffins and Reimeri items are octavos.

volume bound with it, printed also by Meiettus, and written by
Petro Alcmarian, who was interested in the eye.

We all have on our shelves some one book, that, in case of fire, we
are determined to save, come what may. Under such conditions I
shall tarry long enough to tuck safely under my arm a little, worn,
half-vellum octavo volume of the "Frankfort Saurius" edition of
Taliacotius, given me by Leroy Crummer during his last days. This
edition (1598) seems more rare than the first Venetian edition
(Bindonus) although it is quite evidently a reprint with the original
cuts well copied, but reduced in size. It was printed by John Sawrns
and published by Peter Kopffins, who wrote a preliminary dedicatory
epistle for it. The cover is somewhat worn and dilapidated and the
paper is badly foxed, as is the case with so many of the books pub-
lished in Frankfort during this period. The bookplate is that of Wil-
liam Fuller Maitland, Stansted Hall, and bears witness that, like
Black Beauty, it has always been in good hands—until now.

In 1831, G. Reimeri, of Berlin, published a volume edited by
Mr. Troschel, M.D. with a dedication to Dieffenbach and a preface
by the editor, in which he says that "two editions of the work of
Taliacotius had appeared thus far, but that they were very rare. The
older was that which Gaspar Bindonus, the bibliophile, issued in
folio under the supervision of the author himself in Venice, in the
year 1597. Then in the following year," Troschel said, "the same
work was issued in Frankfort on the Main, by Peter Kopffins. It
was in octavo form, in cheaper style, with a text including eulogies,
testimonials and indices, but with fewer typographical errors. At
most, two or three copies of each edition were to be found in Berlin,
and men most versed in the knowledge of books, had told him that
there were but few of them throughout the world." For this reason
Troschel was "moved to issue a new edition in Latin, rather than in
the vernacular, so that it may be accessible to the learned of all
lands." The volume is an octavo, with six lithographic plates. In it
he calls attention to Taliacotius' beliefs in the grafting of buds on
trees, etc., on the basis that human tissue might likewise be planted.
This was very likely the origin of gland therapy (gland grafting).

Taliacotius' background and schooling were excellent, according
to the standards of the day. He was known to be a clever general
surgeon, with a penchant for plastic work on the face, although he did
not claim absolute originality in this branch. However, it was he
who published the first work entirely devoted to plastic surgery, the

subject matter of which may still be profitably perused today.
Quoting Josephus, Taliacotius wrote that in certain countries the
man witht he largest nose was chosen as king, the nose being indica-
tive of character and ability. He classified three types of skin and
recommended rhinoplasty before old age set in. He even went so far
as to determine the best season and the best hour for the operation.
The first postgraduate student to write of his work was Thomas
Feyens, a German pupil (1602).

Taliacotius' work was poorly received outside of Italy and was
met mostly with a discussion as to its possibility or impossibility.
Even in Italy, then the country most advanced in plastic surgery,
there were those who, through jealousy, refused it recognition. We
think of him as the originator of the "Italian Method of Rhino-
plasty," which was in reality the origin of the tube flap, rediscovered
during the World War. After his death, the University of Padua
erected a statue in his honor and another was placed in the Uni-
versity of Bologna. Both have now disappeared (Frank). He was
evidently a good salesman who thoroughly believed in his own sur-
gery, stating that after his new operation had been performed, the
noses could smell more acutely than the old ones. However, his fame
led to great hostility on the part of the church which pursued him
past his grave. He was interred in the Church of San Giovanni
Battista, but when, a few weeks later, the report was circulated that
a mysterious voice was crying out: "Taliacotius is damned," the
remains were exhumed and buried in unconsecrated ground. Inci-
dentally, all copies of his book were ordered to be delivered to the
authorities to be destroyed.

Lampooning of a man high up (who had reported a new proce-
dure), was by no means confined to the general public. It was liber-
ally abetted by the example of Paré. During a very successful
professional life, Paré, called the father of modern surgery,
bequeathed to posterity a monumental collection of manuscripts
on medical, surgical and allied subjects. The first original English
edition of his works (Fig. 5) was published in London, in 1634, by
Cotes and Young and is profusely illustrated. This admirable trans-
lation was done by Thomas Johnson. The folio has a magnificently
engraved title page (author's copy). While dealing but incidentally
with plastic surgery, the volume is extremely important as it is the
first English translation and has numerous illustrations which reflect
the surgical atmosphere that Taliacotius was working in. Paré had

no conception of skin grafts or flaps, but along with Fallopius, maligned "Tag" so bitterly, as further to incite not only the press but the all powerful clergy as well. All of this criticism—from the
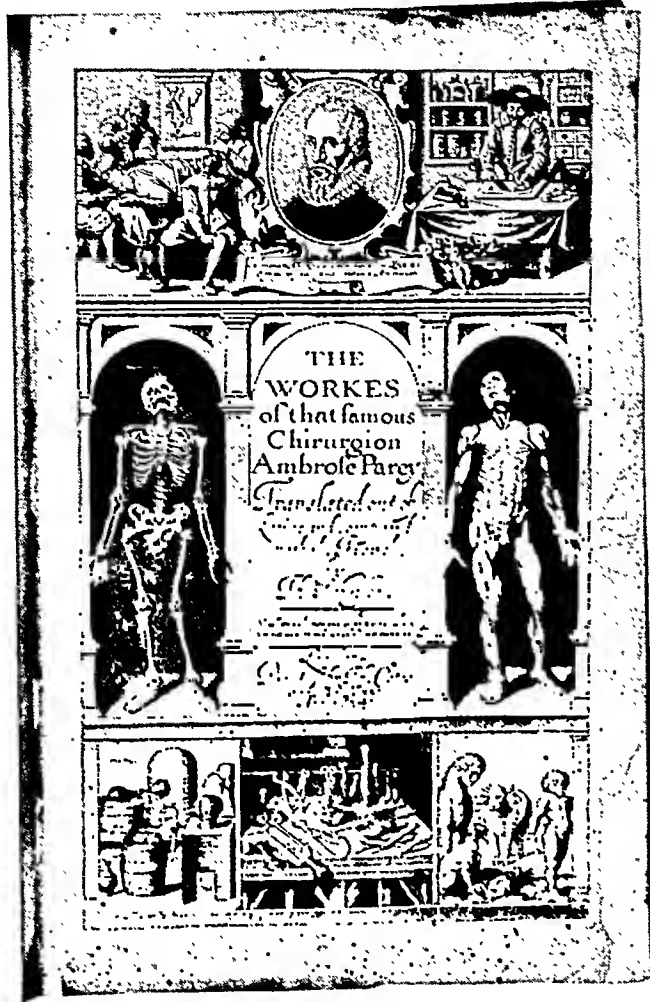
FIG. 5.

Title page of first English translation of Paré's works. Note lower right hand corner has vignette of monstrosities of human and animal mixtures.

man who introduced the use of the ligature as against cautery. His instruments, as depicted in his book, are strangely akin to many of those in use today. He was the first to do a judicial post-mortem (1562). A better understanding of the era in which Paré lived, will tend to soften his condemnation of Taliacotius' "miracles." For instance this: the largest surgical encyclopedia of that time has several chapters, copiously illustrated, which are devoted to monsters

and mermaids. Paré describes them with gusto and his persecution of "Tag" illustrates the old adage of "straining at the gnat and swallowing a camel."

Taliacotius' accomplishments in facial reconstruction occurred at a time when the upper classes were becoming exceedingly vain about raiment and also were becoming, to a degree, face-conscious. There appears constantly in the catalogs of old medical books, a book by Giovan B. Porta (who invented the camera obscura in 1588), written in 1586 and published in 1593. It is entitled *De Humana Physiognomae* and contains, besides portraits of the author and Bishop Aloisius of Este, a great number of interesting woodcuts of heads. My copy is an octavo, bound in old, limp vellum and printed by G. Antonius Hanau in 1593. Besides being important as the first work of its type, it is a forerunner of Lavater in the estimation of human character by the features. One series of woodcuts, those most copied, shows the facial resemblance between humans and animals.

One afternoon, some years ago, a Hollywood bookseller called to tell me that a four volume work, with a "lot of cuts of heads," had been left in his shop for sale. A half hour later the books were on my desk and the gentleman had departed with my check in hand.

The four volumes, octavo, bound in calf, published in 1586, had many cuts, some in silhouette and all carefully analyzed in the text regarding their physiognomy. The author was Lavater, with whom I was unfamiliar at the time. However, the volumes were in good condition and impressive enough to authorize an immediate effort on my part to acquire them, with a fond hope that the bookman was as ignorant of their worth as he seemed. He was not. I had overpaid him liberally, and I began to realize that even old plastic items should be investigated and their value determined before buying. Later I acquired, at a far lower figure, the 1810 edition, a 5 volume folio, translated by Hunter. This is a decidedly more beautiful and luxuriant edition. (Fig. 6.)

The question arises: where does one look for old plastic items and how does one establish prices? Personally, I collect catalogs of old medical books from abroad, issued by perhaps a dozen firms. The descriptions of the books are usually fairly complete. After the price has been translated, I order one, and, out of a fair percentage of cases, if the volume has not been sold when the order reaches the firm, it some day becomes mine.

I have before me three small octavo volumes of Hudibras in the original first edition (1663), containing on page 29, Canto I, the famous stanza regarding Taliacotius and the Porter. The delightful
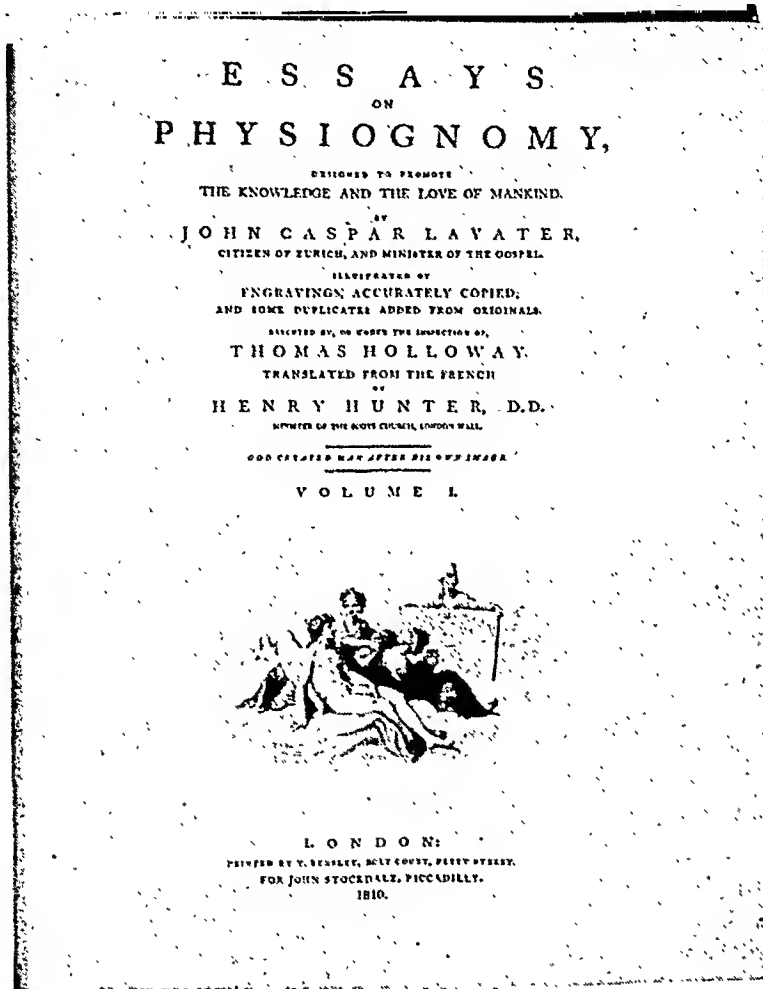
FIG. 6.

Title page of 1810 edition of Lavater. This is a large folio in five
volumes, volume v containing several beautiful engravings of the
Stuart "George Washingtons."

repercussions by Addison and Steele which appeared in the Tatler, December 7, 1710, cannot go unheeded. Steele contended in his column, that all "Tag's" noses were syphilitic and that after the siege of Naples was over, Taliacotius, who had served in it, retired to a little German town and opened a hospital. The space above the portal was embellished with a huge golden nose and the inscription:

"The toils of love require a soldier's art;
And every lover plays a soldier's part."

His first patient, it was said, was a man from Portugal with a swarthy skin. The new nose, according to "Tag," could sneeze, smell, take snuff, pronounce the letter "m" or "n" and perform the functions of any normal nose. His great predicament was, however, that the new nose had been taken from a porter with a white skin, and moreover from an area (der Sitzenplatz) not often exposed to the sun. The contrast was very noticeable. To prevent any future mistakes, he "typed" his donors from about town, thus satisfying trade requirements.

Steele maintained that the Butler Hudibras anecdote was based on a case reported by Von Helmont. The latter had told of a man whose new nose, made from the arm of a laborer at Bologna, was lost when the laborer died three months later. Steele enlarged on the theme and told his own story of three Spaniards, all of whom had their noses repaired from the buttocks of the same porter. Later, when the porter was beaten and kicked, their noses became so swollen that they banded together to protect the donor, who, it was said, "led them by a nose." On the other hand, when the new noses would react to the smelling of pepper or the eating of mustard, the incisions from which the grafts came, began to "itch, burn and have unspeakable twinges."

The scholastic tempest, aroused by the appearance of Taliacotius' book, had other marked reverberations. A half dozen men claimed precedence over him in their unpublished or manuscript-reported cases. Others, like Paré, openly denied the possibility of such things. The church, being the deciding power at that time, saw an opportunity to combat the encroachments of science upon its influence. It proclaimed that "Tag" was interfering with the work of God. The fall of plastic surgery as a specialty was at hand! In 1778 the whole subject had so depreciated, that the Paris Faculty forbade any further facial surgery; in fact, in the seventeenth and eighteenth centuries, the art of facial restoration was in such disrepute as to become almost forgotten. The fall of plastic surgery was then complete—due to the professional jealousy of its adherents.

Our scene changes to London at the opening of the nineteenth century. At that time anything of a surgical nature was a matter of high society interest. Printed invitations were issued for post-mortems and the engravings we see of the formally dressed lords and ladies, as well as the dissectors, around the occupied slab, were quite in keeping. The first monthly magazine had just appeared,

its contents, like many of the present day, were composed of items both of fiction and of semi-scientific interest. Called the Gentleman's Magazine, it ran in 1794, several columns of a correspondent's letter from India, which had been recently acquired as a British possession. It described total rhinoplasty in India and the illustrations by Longmatice may be those of the author, who signed himself "B.L." Here was direct proof of the actuality of total rhinoplasty from a very different part of the world. It furnished a choice bit of drawing-room conversation. The satires of Samuel Butler and Steele were revived and discussions of artificial noses and prostheses of various sorts became common. These were finally elaborated upon in Lawrence Sterne's "Tristram Shandy," published in 1813. His main character wore a large nose, a prosthesis so well made as to challenge detection, which excited interest on the part of the females, so the story goes, who credited him with similar endowments of the rest of the body. As a result, the public, ready for a laugh, Rabelaisian though it might be, began to accept a more placid view on the subject of plastic surgery.

In 1816, Joseph Carpue reported several cases of total rhinoplasty, performed by himself in England. The English spoke of this particular procedure as "the nasal operation" and Carpue was the first to use the expression "restoring a lost nose."

A package came to me from Zurich one morning, in response to a standing order of several years, containing a large, flat volume, entitled "Rhinoplastik," written by Dr. Carl Ferdinand Graefe, and published in Berlin in 1818. It is in a contemporary board cover, with pages neither cut nor washed and title page intact. It has 210 pages and is illustrated with six large folding plates depicting various stages of total rhinoplasties in a manner somewhat reminiscent of Taliacotius, especially in the "cucullus" or retentive apparatus. (Fig. 7.) Incidentally, this is the first monograph on the subject of rebuilt noses since Taliacotius. Graefe was also greatly interested in eyelid reconstruction and was the first to coin the word "rhinoplastic" from which all other similar names were formed, viz. cheiloplastic, blepharoplastic, etc.

In the same package was a thick, little volume comprising the first three editions of Dr. J. G. Dieffenbach, "praktischem Artz" in Berlin, entitled *Chirurgische Erfahrungen, besonders über die Wiederherstellung Zerstorter Theile des menschlichen Körpers, nach neuen Methoden*. The title page stated "mit zwei lithographirten Abbild-

ungen" and the publisher's date was 1829. Of the first edition there were only a hundred pages and the illustrations were bound together with those of the second edition (1830) of 200 pages and twenty-one

FIG. 7.

A folding plate from Carl Graefe's "Rhinoplastik," first edition published in Berlin in 1818. The retentive apparatus on the left seems little changed from the cucullus of Taliacotius 200 years previous. This is one of six plates 10 × 16 inches illustrating his book.

illustrations, all of which are on elaborate folding pages, with Plate XXI in color. The second edition was twice the size of the first, and, as if to keep pace with an established precedent, the third was three times as large. It was issued in 1834, had three hundred pages and was dedicated to Dieffenbach's friend, Dr. Jungken. Most of the illustrations pertain to total rhinoplasty, although a few plates of eyes and ears are included. (Fig. 8.) Although the drawings (lithographs) of that era are excellent, one cannot help but wish for the actual photographs of today in order to judge fairly the post-operative results of the renowned doctor.

Dieffenbach was the first to call attention to the psychological boost of rhinoplasty to the patient. In his description of making an entire nose from the skin of the upper arm, he advises the use of "blood-suckers" or leeches on the congested flap. One of the newest phases of present-day medicine deals with the use of hirudin (active

principle of leeches, reducing blood coagulation time) for dissolving cerebral thrombi. And here was Dieffenbach, in the early nineteenth century, dissolving congested circulation in arm flaps by means of
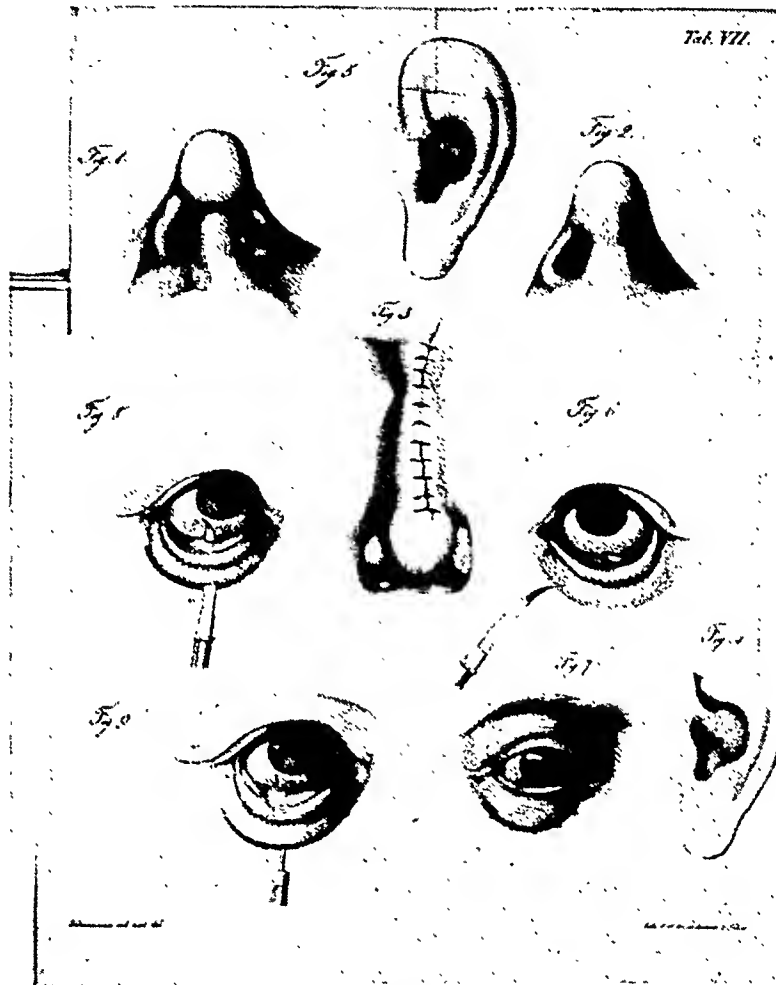
FIG. 8.

Dieffenbach, in addition to being the greatest plastic man of his time, went into great detail in his illustrative efforts. His three books from 1829 to 1834 contained twenty-five well done lithographs of rhinoplastics, including the rare plate on the eye, ear and nose here depicted.

direct application of blood-suckers! Dieffenbach stated that a rebuilt nose might be large or small, but it had no anatomic use; the rebuilt lip had only to cover the teeth and keep the spittle in the mouth; but the reconstructed eyelid must work. Therefore that was truly a worthy operation, since the eye should have some protection. His many contributions to the literature stimulated a great new interest in plastic surgery and this was aided by the introduction of anesthesia; the continent was soon abuzz with men reporting and writing up cases amenable to the new technique.

The first half of the nineteenth century found the literature of plastic surgery increasing rapidly. My old-book catalogs on plastic surgery of this period became more fruitful, my shelves heavier and

DIE

LITERATUR UND GESCHICHTE

DER

PLASTISCHEN CHIRURGIE.

VON

D.͇ EDUARD ZEIS.

LEIPZIG,
VERLAG VON WILHELM ENGELMANN.
1863.
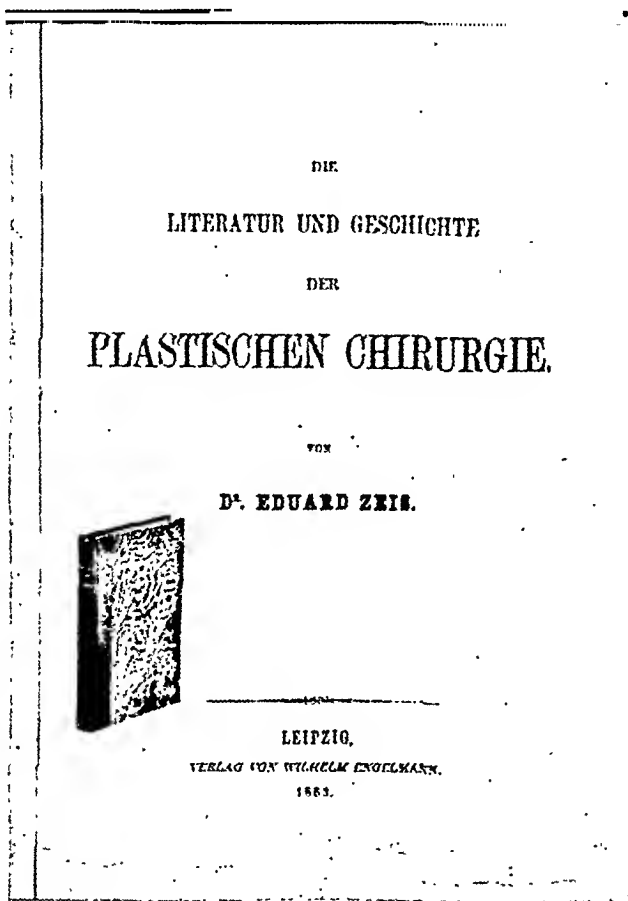
FIG. 9.

This title page of Zeis with the inset picture of the volume itself is of the first edition published in 1863. The book represents many years of extremely conscientious and brilliantly productive work. There is no mention in Garrison or Pilcher.

my purse lighter. Following a "book-folks" dinner at his home one night, my preceptor, Leroy Crummer, tucked a little volume under my arm at the door, remarking that it might be of interest. (Fig. 9.) The title was *Die Literatur und Geschichte der plastischen Chirurgie* and the author Dr. Eduard Zeis; it had been published by Wilhelm Engelman in Leipzig, in 1863. The work was an elaboration of Zeis's *Handbuch der plastischen Chirurgie*, published in 1838, and had a foreword by Dieffenbach. Naturally, I looked to see what Zeis had to say about Taliactious and found, to my delight, his comment

on Voltaire's mention of Butler's Hudibras in the French version.

The reproduction of the famous verse in the original with the added variations in the French and German of that time give a deeper insight into the temper of the age.

> "So learned Tagliacotius, from
> The brawny Part of a Porter's Bum,
> Cut supplemental Noses, which
> Would last as long as Parent Breech;
> But when the Date of Nock was out,
> Off Dropp'd the sympathetick Snout."
>
> Butler (1710)

> "Ainsi Talicotius,
> grand Esculape d'Étrurie,
> répara tous les nez perdus
> par une nouvelle industrie:
> il vous prénoît adroitement
> un morceau du cu d'un pauvre homme,
> l'appliquait au nez proprement;
> enfin il arrivait qu'en somme,
> tout juste à la mort du prêteur,
> tombait le nez de l'emprunteur,
> et souvent dans la même bière,
> par justice et par bon accord,
> on remettait au gré du mort
> le nez auprès de son derrière."
>
> Voltaire version (1785)

> "So macht es Doctor Tagliacott,
> der Nasen aus Kneblers Hintern schnitt;
> die sympathet'sche Nase klebte,
> so lange Vater Podex lebte,
> doch streckt' der Knebler den in's Grab,
> so fiel die Nase gleichfalls ab."
>
> Soltau version (1797)

The more one studies Zeis's book, the more apparent it becomes that it is the fountainhead for all articles concerning the literature on plastic surgery up to 1859. For instance, regarding older references, he felt that many errors had crept in, since the dates had been handed down from author to author without checking the origin. He therefore verified as many quotations as possible by personal research into the works themselves.

The volume is an octavo, with board covers, and consists of three principal divisions:

    I. The Literature of Plastic Surgery.

        Pages 1–182 inclusive. There are 2008 notations and excerpts (verbatim) from published papers and books, numbered consecutively. In each of the twenty chapters devoted to the various specialties, the authors are named alphabetically (beginning anew with "A" in each chapter.)

    II. The History of Plastic Surgery and It's Literature.

        Pages 185–290 inclusive—elaborate in detail, chapter by chapter, the most important notations in the first division, and are so marked.

    III. A Supplement of Corrections and Additions.

A casual perusal of the book reveals much. To quote the author: "As far as I know, I was the first to use the words 'plastic surgery.'" He justifies the different spellings of authors' names in his book by stating that he does it for the sake of variation; that they may all be recognized, whether it is in German, French, Italian or English. For instance, he often calls Taliacotius "Tagliacozzi"; and states that he speaks of himself sometimes in the singular and sometimes in the plural form for variety and partially for modesty's sake. This is about as good a reason as I have found.

Incidentally, Zeis states that, although according to authorities, "Tag" had added nothing new to what the Italians (Brancas) had already done, his otoplastics were patterned after the methods of India, thus proving that some knowledge from the far East must have filtered through. Zeis speaks of Creutzenfeld and Pfeiffer's "Universal Repertory" as a source book, containing lists of already published plastic articles. He evidently had access to everything in Berlin, but had trouble in finding complete files of English medical journals. He says: "there is no doubt that this, the first half of the nineteenth century, is the golden age of plastic surgery."

Almost a hundred years ago Zeis listed over 2,000 papers and books on plastic surgery, lamenting that his list was so incomplete. In spite of its history, derogation and downfall, the rise of plastic surgery by its own merits has been so steady and consistent as to place it today as the pinnacle of surgical achievement. In conclusion, then is the answer to the question so often asked us: "Has plastic surgery just been in existence since the World War?" Our answer is, "*It has existed since war began!*"

EDITORIAL

THE ARTIST VIEWS AMERICAN MEDICAL PIONEERS

THE Interstate Post-Graduate Medical Assembly this fall introduced to the medical profession and to the public at large the first of a series of paintings commemorating notable figures in American medicine. Dean Cornwell, noted American illustrator and mural painter, has set out to familiarize Americans with the achievements of American pioneers in the medical arts: Beaumont, the father of modern experimental physiology; Ephraim McDowell, the father of abdominal surgery; Dorothea Lynde Dix, crusader for improved conditions for the feeble-minded and insane; Oliver Wendell Holmes, who brought to light the contagiousness of childbed fever; Crawford W. Long and William Thomas Green Morton, first to use anesthesia; and Walter Reed, investigator of yellow fever. These men deserve a place as noteworthy as the familiarity already accorded the great Europeans, Lister, Pasteur, Jenner, et al.

Mr. Cornwell's first painting depicts the work of William Beaumont, the army surgeon who developed much of our knowledge of gastric physiology through his study of Alexis St. Martin, the man with "a lid on his stomach." The famous accidental fistula from which St. Martin suffered enabled Beaumont to record the movements of his stomach during digestion, the normal appearance of the gastric mucosa, the effect of temperature and emotional factors upon the flow of the gastric juice, the results of starvation, over-feeding, mastication, and the fact that only the taking of food, and not mechanical irritation, stimulates gastric secretion. That Beaumont lacked scientific education, university degrees and laboratory facilities seemed never to prevent him from perceiving the significance of an accidental finding and developing to the utmost the opportunity which had come his way.

The fistula method, originated accidentally through gun-

shot, has since been perfected by Pavlov and his school. The data accumulated by Beaumont have since been expanded into a large and growing body of knowledge. That his contribution should at last be popularly recognized and the drama of his story known to millions is a belated tribute.

The artistic merits of Mr. Cornwell's painting must be left for others to discuss.

We have from the artist himself the assurance that he spent many months in research in order to portray the characters and the locale of the experiment with accuracy and fidelity. As a result, the historian will appreciate his work, and millions of Americans will find in it an interesting illumination of a phase of American history thus far little studied.

T. S. W.

GEORGE WILKINS SWIFT

IT is with regret that we announce the sudden death on December 18, 1938 of George Wilkins Swift of Seattle, nationally known surgeon and member of the Editorial Board of The American Journal of Surgery.

Dr. Swift since his graduation from Northwestern University Medical School in 1907 has risen far in the neurosurgical field. He was a fellow and member of the board of governors of the American College of Surgeons, a past president of the Pan-Pacific Surgical Association, the Pacific Northwest Medical Association and the Public Health League of Washington. His many contributions to this and other journals have established his reputation as an authority on neurosurgery. Only two weeks before his death, his last article was published in the December number of The American Journal of Surgery.

To his relatives we, in the name of The American Journal of Surgery, offer our deepest expression of sympathy.

T. S. W.

A NEW METHOD OF JOINT MEASUREMENT AND A REVIEW OF THE LITERATURE

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ROCHESTER, MINNESOTA

IT is the purpose of this paper to introduce a system of measurement which, it is hoped, will simplify and standardize methods of measuring joint motion, since there seems to be some confusion and disagreement among physicians and physical therapy technicians regarding terminology, methods and instruments for measuring and recording joint motion.

Accurate measurements of joint motion furnish objective facts on which the physician may gauge improvement or lack of improvement during treatment instead of relying on subjective impressions. Also, by means of accurate measurements of the amplitude, strength and rapidity of movement in the impaired joint, the patient is shown the nature and rate of his recovery. One of the greatest values of joint measurement lies in its physiologic effect on the patient in interesting him in the progress of his own case. The initial measurements (Fig. 1) show him the extent and the nature of his injuries as compared with the normal; succeeding measurements show him how rapidly he is improving and indicate how long treatment will be necessary. In daily practice, therefore, such measurements furnish the best possible guide to the direction of the treatment itself, and, finally, when the treatment is completed, they furnish reliable data by which the results can be stated.

The need for accurate instruments and methods of measuring and recording joint motion was best seen during and after the World War when so many disabilities had to be treated and recorded. Today there is just as great a need for accurate reports. Those in charge in various industries are demanding reports on all injuries sustained by their employees. They want to know the extent of the injury, the length of time the employee will be absent from work and the progress he is making under treatment. The physician must be able to give such a report on the condition and progress of his patient, and he must give his report in such a manner that it will be understood by everyone who reads it. Measurement of the range of motion in a joint is also the objective test of disablement and is indispensable in medicolegal work. Rosén has stated that: "Exact knowledge of the extent of disability present is of paramount value in medical reports. Laws providing compensation for injuries sustained in industry are now becoming well nigh universal, and the physician is often the sole arbiter as to the amount of disability present. The justice of the compensation awarded depends on the accuracy of the records."

A recent survey of the literature has revealed a variety of methods for measuring the limits of motion or the angle of deformity in joints. A few physicians have worked out systems of measurement and methods of recording joint motion which they uniformly use, and these methods,

once explained, are intelligible and can be clearly understood. It was found, however, that the majority of physicians gave little

methods of measuring joint motion, the types of instruments used for this purpose, and methods of recording such measure-
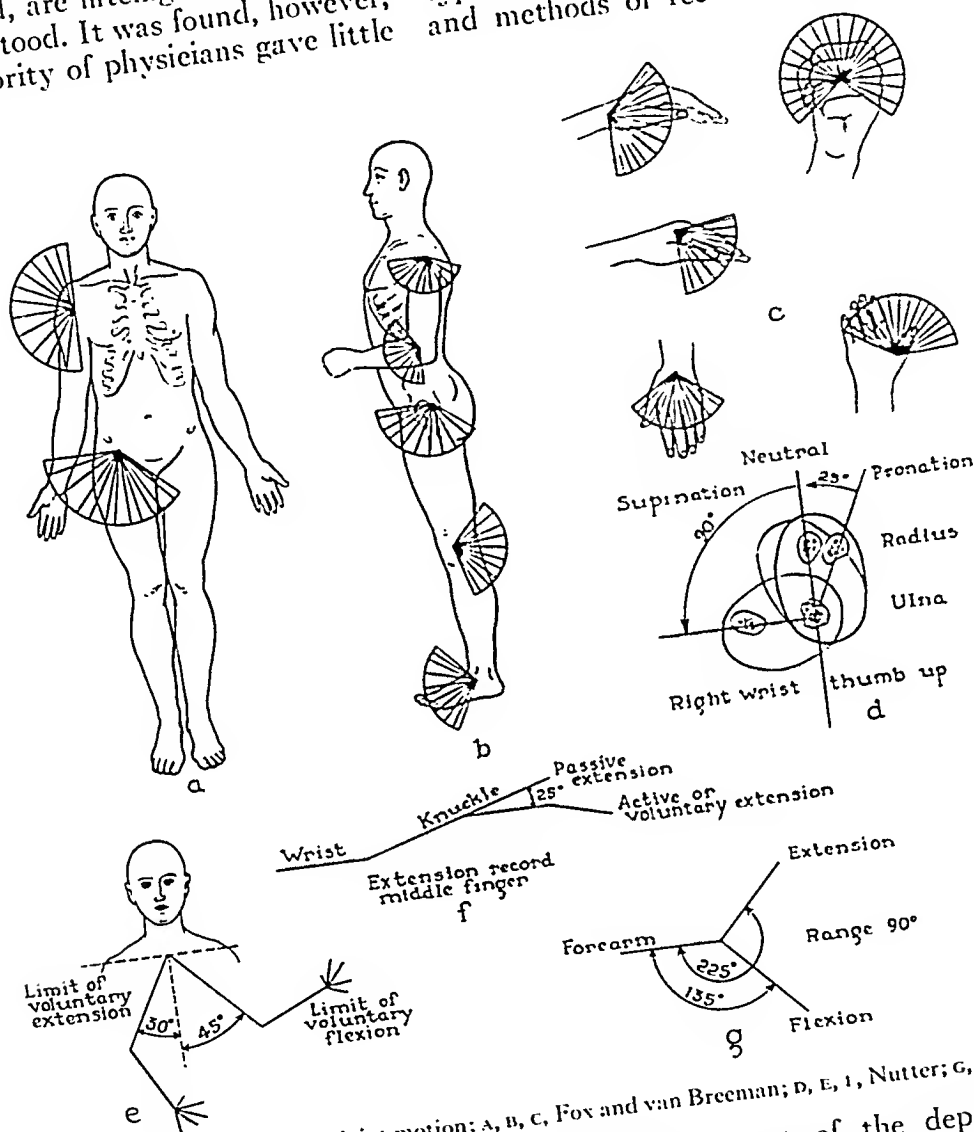
Fig. 1. Methods of recording joint motion: a, b, c, Fox and van Breeman; d, e, f, Nutter; g, Rosén.

thought to the matter. When the necessity arose they gave visual approximations or quickly devised a method to measure motion in the joint, with the result that no one but the particular physician himself could interpret such measurements; indeed it is doubtful whether even he, after a lapse of time, could have understood his own records. In addition, the recent literature was found to contain very little data concerning the measuring and recording of joint function.

On a recent tour of a number of Eastern hospitals inquiry was made concerning

ments. In most of the departments of physical therapy that were visited it was found that no definite system was used and that, as a rule, no records of joint measurements were kept. The range of motion in an affected joint was usually approximated visually.

Existing methods for measuring and recording joint motion vary considerably and, when grouped together, may be very confusing. Of the methods of joint measurement described in the literature those of Clark,[3] Robinson,[12] Silver,[14] Rosén,[13] and Cave and Roberts[2] seem to be most clear

and systematic; yet even among these authors there was a wide variation in methods and in nomenclature. Nearly all of

There was likewise found to be a difference of opinion among these same authors concerning the normal range of joint

TABLE I

VARIOUS METHODS GIVEN TO DESCRIBE THE NORMAL RANGE OF JOINT MOTION

	Silver		Clark		Robinson		Rosén	
	Flexion	Extension	Flexion	Extension	Flexion	Extension	Flexion	Extension
Elbow	140°	0°	30°	180°	55–45°	180°		
Wrist	70°	70°	100°	180°	110°	145°	135°	225°
Hip	130°	0°	60°	180°	60–50°	135°		

these men agreed that there should be a neutral point from which measurements should begin, but there was a difference in opinion as to what this neutral point should be: Clark, for example, called his starting position, "a straight line or an extension of the joint," the part distal to the joint concerned pointing toward the toes and being parallel to the lateral plane of the body. Cave and Roberts, on the other hand, stated that, "the joints are not always in extension and the neutral position must be defined." Robinson called his starting point, "the base line and axis of motion in each joint." In his system the long axis of the proximal bone member of the joint under observation was the base line and crossed the axis of motion at a right angle. Rosén did not believe that a definite starting point or neutral position was possible, stating that, "of most concern is the size of the angles subtended at the two extremes of excursions of the joint; the difference between these two gives the range of motion, which, when compared with the normal, expresses the disability present." Silver, on the other hand, proposed that "mensuration of the degrees of motion in joints should start from a zero plane. The zero plane shall be considered to be an extension of the plane of the long bone or bones immediately proximal to the joint in question."

motion. (Table 1.) From this table it can be seen that each gives different figures to describe the range of motion in the same joint. It is just for this reason that such confusion exists in the literature on joint measurement. It is particularly to be desired that a starting figure be agreed on, since if there is any difference in this figure it naturally follows that there will be a difference in the resultant combinations even when the same amount of movement is expressed, and figures for describing the range of motion will vary according to whether the measurement starts from extreme flexion or extension or from some other starting point. In one report, for example, the angle subtended by the hand and forearm when in a straight line was considered as zero; in another it was called 180 degrees. Some authors compute the range of supination from full pronation; others from mid-pronation. It would probably be wiser to state that the degrees of normal motion are approximate, as ranges of motion will vary in different individuals. A range of motion which may be normal in one will not be possible in another. The normal range of movement will depend, therefore, on the age, sex, habits and occupation of the individual.

There was also confusion regarding the terms used to describe the many movements of the bony articulations of the

body. In the case of almost every joint studied a variety of terms was used to describe the same movement. For example, "inferior" or "superior," "adduction" or "abduction" were used in contexts where the meaning was by no means clear. In

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PHYSICAL THERAPY DEPARTMENT
JOINT MEASUREMENTS

Name_____ Hospital No._____ Date Ref._____

Diagnosis_____ Clinic No._____·_____

Dr. Referring Case _____ Dept._____ Intern_____

Left						SHOULDER						Right	
						Flexion							
						Extension							
						Abduction							
						Adduction							
						External Rotation							
						Internal Rotation							

a

Joint Measurement

b

c
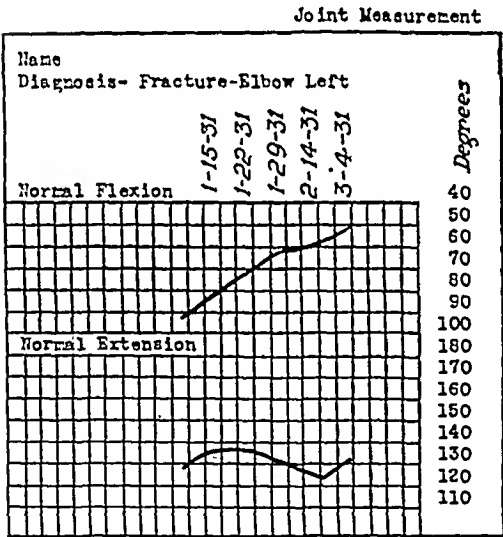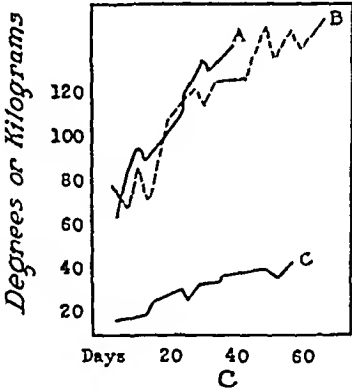
Joint: Knee	Motion on adm.	Motion on dis.
Ext. to :	:	:
Flex. to:	:	:
Range :	:	:

d

Fig. 2. Methods of recording joint motion: A, B, Molander; C, Albee and Gilliland; D, Krusen.

thirty-seven different terms were applied to movements of the humerus alone. Such terms as "coronal," "sagittal" and "median" planes; the "pivotal position"; and addition, such terms as "circumduction," "rotation," "elevation," "flexion," and the "neutral position" were too frequently used ambiguously.
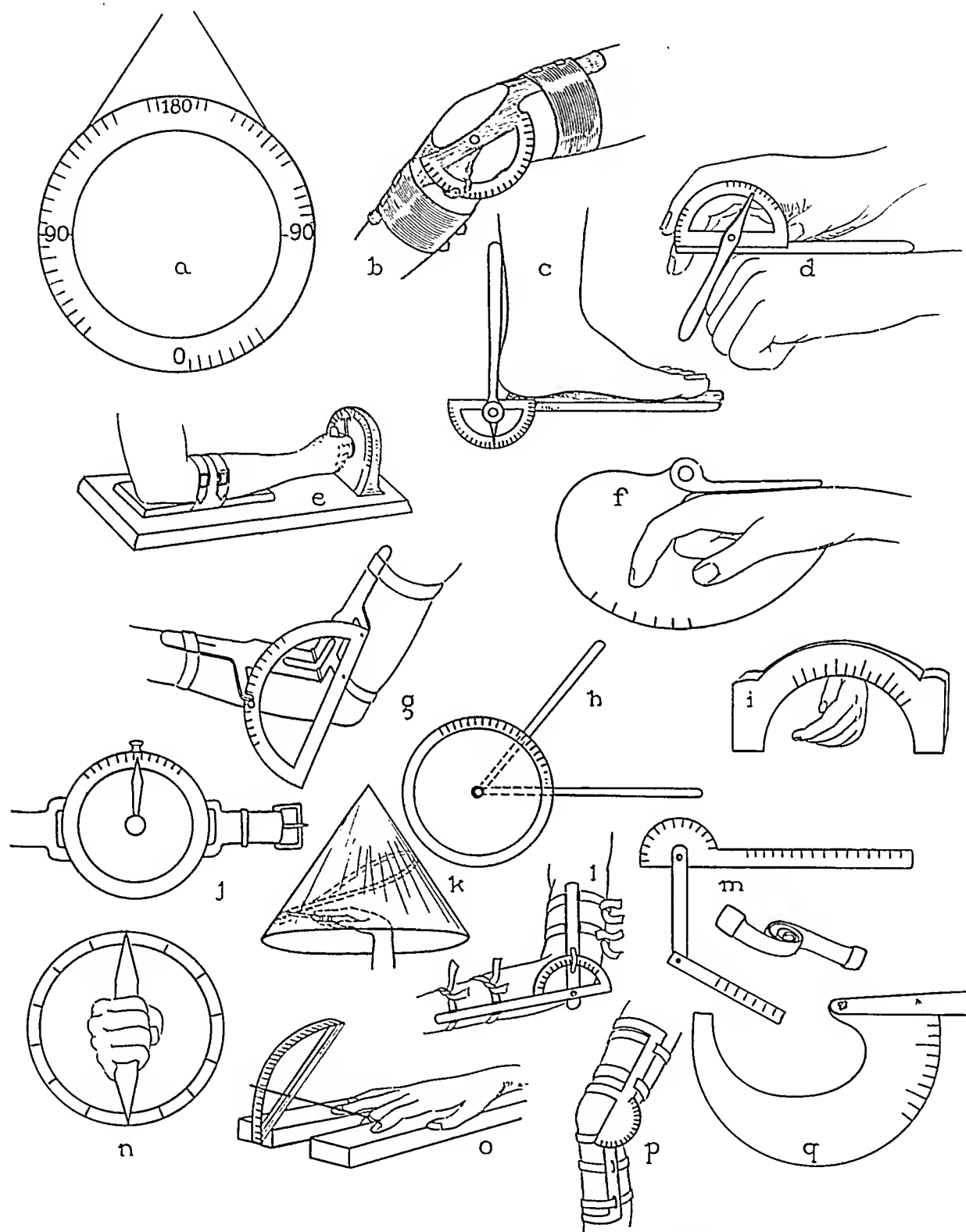
FIG. 3. Instruments used for measuring motion in joints: A, for measuring hip and shoulder, Rosén; B, goniometer for knee; C, fleximeter for ankle and wrist; D, fleximeter for fingers; E, device for measuring supination and pronation, Fox and van Breeman; F, phalango-fleximeter, Rosén; G, fleximeter for elbow joint, Fox and van Breeman; H, fleximeter for elbow joint, Rosén; I, protractor for measuring rotation; W. A. Clark; J, pendulum arthrometer, Fox and van Breeman; K, schematische Kegelprojektion, Mann; L, Winkelanalysator, Filimonoff; M, protractor that can be folded easily, Robinson; N, marking pronation and supination with a pencil, Cleveland; O, fleximeter for fingers, Albee and Gilliland; P, fleximeter for knee, Albee and Gilliland, and Q, protractor scale, Follweiler.

VARIOUS CURRENT METHODS OF
RECORDING JOINT MOTION

It is generally accepted that measurements of joint movement and deformity should be recorded and that such records should be absolutely intelligible. These records serve a purpose similar to that of the temperature chart or sphygmographic or electrocardiographic record. Albee and Gilliland, Rosén, Robinson, Fox[7] and others have employed such records to indicate whether recovery was taking place as it should and, if not, as an indication that a change of treatment, or possibly an operation, was necessary. If recovery is not taking place uniformly, this fact is brought out in the series of measurements, and the chart indicates where most attention should be directed. When the surgeon has a large number of patients under his care, it is, of course, impossible for him to remember the condition of each one or his needs and progress; by a system of accurate and clear records, however, it is a simple matter for him to see at a glance just how each one is progressing.

Various methods of recording such measurements are used by the medical profession, ranging from hastily scribbled notes on the patient's history of the deformity or extent of limited motion to elaborate photographing and graphing of degrees of movement on special graph paper:

Photographs. The usual method of recording joint function is to take a picture of the part at the time treatment is begun, to show the extent of movement possible. Photographs are then taken at regular intervals and at the time the patient is dismissed. A comparison of such photographs will not only show the progress of movement in the part, but also the patient's general condition, the amount of atrophy, the degree of deformity, and so forth. This method is very satisfactory but is costly and time-consuming.

Schematographs. This is a comparatively new method of recording movement. The part is placed in front of a white background with lights shining on it from two directions. The outline is then traced out while the part goes through all of its ranges of motion. Tracings can be made at frequent intervals and comparisons made to note the amount of improvement that has taken place. In this method the various movements of the part are recorded easily on one piece of paper. The apparatus used for recording consists essentially of a box, into which is mounted a camera lens, a mirror to reflect the image, and a piece of clear glass which is placed over an opening above the mirror. The image of the part will be seen on this glass and can then be traced on tracing paper. The difficulty with this method is that, unless the recorder has some skill in drawing, the diagrams will not be very accurate.

Graphs. This method is used quite frequently by physicians and technicians in recording the amount of motion and degree of improvement. In order to insure clearness, a key to the graph or some explanation of the curves must be given. (Fig. 2, B and C.)

Simple Recordings. A simplified method of recording used by many is merely to mention in the patient's history at the time of measurement, the part, the movement being measured, and the findings. For example, for the right elbow: flexion to 130 degrees, extension to 180 degrees; range of motion 50 degrees. (Fig. 2, A and D.)

Diagrammatic Drawings. Nutter[10,11] stated: "Greater use should be made of geographic (sic) records in the interest of clearness. Diagrams will make plain what we mean, even though we differ in our terms. These graphic records take very little time to sketch free hand. If actual measurement in degrees of a joint is wanted the sketch is used and the angles are measured." (Fig. 1D, E, F, and G.) Here again, unless the illustrator can make his diagrams quite clear, the records will not be intelligible.

Apparatus. The necessity for treating and recording disabilities sustained in the

World War stimulated the development of a great many instruments for measuring the amplitude of movements in various

about the limb and have a dial from which readings can be made. According to Robinson, the original instrument for
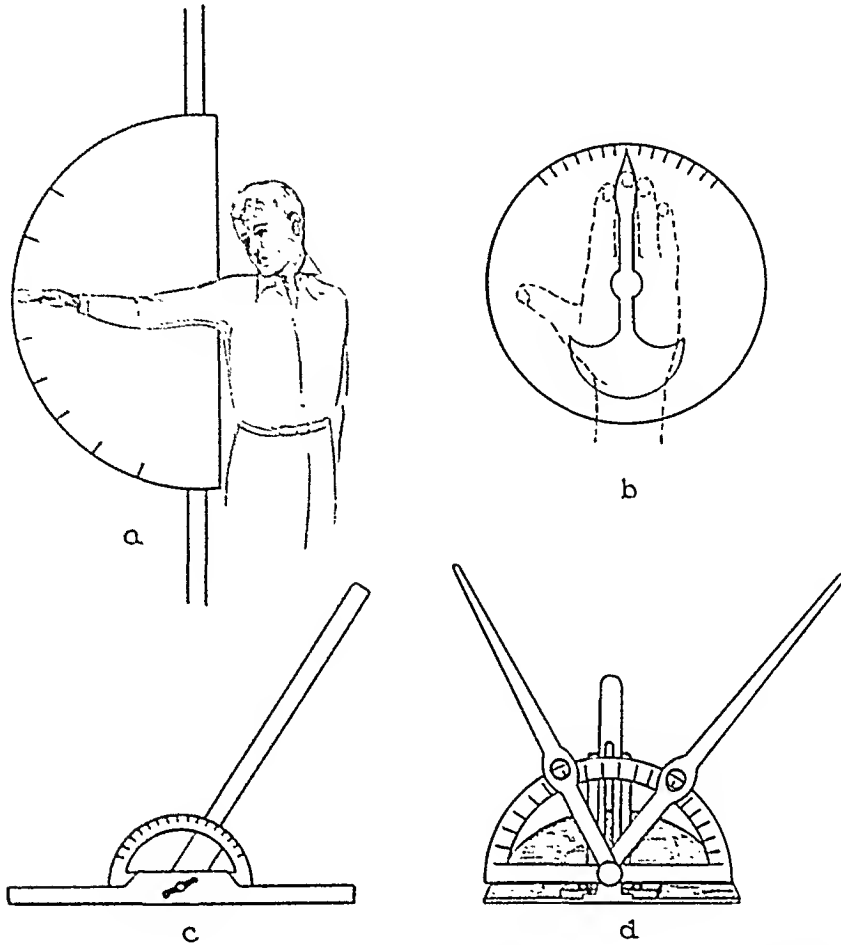

Fig. 4. Instruments used for measuring motion in joints: a, for shoulder, Albee and Gilliland; b, for abduction and adduction of wrist, Albee and Gilliland; c, wood protractor, Krusen, and d, type of protractor used at present at the Mayo Clinic, Krusen.

joints. Nearly as many instruments have been devised as there are joints in the body, among them goniometers for measuring motion in the knee joint, protractors for shoulder joints, fleximeters for elbow, ankle, wrist and finger joints, and special instruments for measuring supination and pronation. These instruments have also been used to measure the amount of angular deformity of a fracture in a roentgenogram, and occasionally they are used in designing braces.

Such instruments vary widely in design. Some are elaborately constructed of metal framework and demand a special technique for accurate use; others are quite simple copper or wooden frames that fit over or

measuring joint movement was a protractor so modified that it could be used on all of the extremities. It consisted essentially of two arms, to the end of one of which was attached a protractor scale, the end of the other arm being shaped to a pointer. These arms were connected at the axis of the scale so that the pointer registered on the scale. Instruments and apparatus in present use or that were used formerly are illustrated in Figures 3 and 4.

A NEW SYSTEM OF JOINT MEASUREMENT

The system of measurement now in use at the Mayo Clinic is based on the half circle arc. Movements are measured either from 0 to 180 degrees or from 180 to 0

degrees. Wherever the part stops in its course on the scale (Fig. 4D), the number opposite the part indicates the degree of

extension may be stated as flexion or extension to the number of degrees indicated on the scale.

TABLE II
NORMAL LIMITS OF MOTION

I. Shoulder:
    A. Neutral position: Patient lying, arm extended at side, palm down.
        1. Forward elevation (flexion): 180° to 0°.
        2. Extension: 0° to 180°.
    B. Neutral position: Patient sitting, arm extended at side.
        1. Backward elevation (hyperextension): 180° to 135°.
    C. Neutral position: Patient lying, arm extended at side.
        1. Sideward elevation (abduction): 0° to 180°.
    D. Neutral position: Arm extended sideward, straight with shoulder line, elbow bent at an angle of 90°. The arm is in midposition between inward and outward rotation.
        1. Inward rotation, 180° to 0°.
        2. Outward rotation, 0° to 180°.

II. Elbow joint:
    A. Neutral position: Patient lying with arm extended, palm up.
        1. Flexion, 180° to 45°.
        2. Extension, 45° to 180°.
    B. Rotation in radio-ulnar articulation. Neutral position: Midposition between pronation and supination. Scale to read 90°. Measure with the fingers extended.
        1. Pronation, 180° to 0°.
        2. Supination, 0° to 180°.

III. Wrist joint:
    A. Neutral position: Hand and wrist in midposition between pronation and supination, the wrist straight.
        1. Flexion (palmar flexion), 145° to 30°.
        2. Extension (dorsal flexion), 30° to 145°.
    B. Neutral position: Hand in midposition between adduction and abduction. Scale to read 90°.
        1. Abduction (ulnar flexion) to 165°.
        2. Adduction (radial flexion) to 55°.

IV. Metacarpophalangeal joints (after Clark):
    A. Neutral position: Fingers in extension.
        1. Flexion, to 90°.
        2. Extension, to 180°.
        3. Hyperextension, to 140°.
        4. Abduction (varies for different fingers).

V. Finger joints:
    A. Neutral position. Fingers in extension.
        1. Flexion (proximal joint), to 75°. (distal joint), to 90°.
        2. Extension, either joint, to 180°.
        3. Hyperextension, slight and quite variable.

VI. Thumb:
    A. Neutral position: Thumb alongside the forefingers and extended.
        1. Adduction, to 170°.
        2. Abduction, to 130°.
        3. Extension, to 180°.
        4. Flexion (with wrist), to 90°.
        5. Hyperextension (with abduction), to 110°.

VII. Hip:
    A. Neutral position: Patient lying supine, leg extended.
        1. Forward elevation (flexion) with knee bent, 180° to 60°. With knee straight, 180° to 90°.
        2. Extension, 60° or 90° to 180°.
    B. Neutral position: Patient lying prone, leg extended.
        1. Backward elevation (extension or hyperextension), 180° to 135°.
    C. Neutral position: Patient lying supine, leg extended.
        Sideward elevation (abduction), 0° to 45°.

VIII. Knee:
    A. Neutral position: Patient lying prone, leg extended, knee straight.
        1. Flexion, 180° to 45°.
        2. Extension, 45° to 180°.

IX. Ankle:
    A. Neutral position: Patient lying supine, the outer border of the foot held at 90° with the leg out in midposition between inversion and eversion.
        1. Flexion (dorsal flexion), from 155° to 60°.
        2. Extension (plantar flexion), from 60° to 155°.

X. Foot:
    A. Neutral position. Cannot be defined; measurements vary for every part.
        1. Eversion   } Subastragalar
        2. Inversion }
        3. Adduction }
        4. Abduction } Mediotarsal
        5. Flexion   }
        6. Extension } Metatarsophalangeal

motion. The number of degrees, as will be seen in the records of this system, indicates the limit of motion on the half circle scale and not the amount of motion. Flexion and

The zero end of this arc is toward the head and median line of the body. As movement approaches the head, the angle of the joint becomes smaller and reading on

the scale will be less. Motion away from the head will increase the angle, and the reading on the scale will be higher. The same is true when measuring toward and away from the body; the angle of motion will decrease as it approaches the median line and increase as it moves away from the median line. In rotation, including pronation and supination, the zero end is toward the median line of the body. Extension is movement toward 180 degrees, flexion toward 0 degrees, and the half circle arc in the anteroposterior plane. Hyperextension is movement toward the head, and measurement will read from 180 to 0 degrees. Measurement of adduction will read toward 0 degrees and of abduction toward 180 degrees. These measurements are made with the arm in the prone position in the lateral plane. Internal rotation is toward 0 degrees and external rotation toward 180 degrees on the anterior half circle arc in the transverse plane.

Neutral Position. The neutral position is that position of the joint from which measurements shall proceed. From this position the joint will begin on its course of movement. Readings on the scale may begin either from 0, 90, or 180 degrees. The normal limits of motion for each joint as here given can be considered only as approximate. (Table II.)

A SIMPLIFIED INSTRUMENT FOR JOINT MEASUREMENT

An instrument has been devised at the clinic by which any joint in the body can be measured. (Fig. 4D.) With only a moderate amount of care in placing it and in taking the reading, as great accuracy is attained as with a much more complicated apparatus. This instrument consists essentially of a stand which is joined to a higher upright. A protractor scale is attached to this upright in such a manner that it can be moved upward and downward in the vertical plane; or the stand can be detached and the protractor can be used in the horizontal plane. Also attached to the upright are two long arms. These move along the scale and

facilitate movement and reading of joint motion. The reading is taken by placing the instrument so that its little axis pin is over one end of the axis of motion of the joint under observation, the upper arm corresponding as nearly as possible to the long axis of the bone above the joint and the other arm, being in the same relationship to the bone or bones below; the upper arm of the instrument is held firmly in position either by hand or by straps, while the lower bone member of the joint is moved in one direction to its fullest extent. The reading is then taken on the scale. Following this, motion is made in the opposite direction and the reading is taken again. Thus there is determined the number of degrees of motion allowed and the relationship of the extreme positions to the axis of the proximal bone.

SUMMARY AND CONCLUSIONS

There is definite need for a systematic and uniform method of measuring and recording joint motion, which is clearly shown by records in medicolegal cases, of industrial compensation boards and by statements of physicians.

As a result of recording measurements, there is a markedly beneficial psychologic effect when the patient can follow his progress graphically. Accurate measurements, however, necessitate a uniform system of measuring joint motion. Various current systems are discussed and instruments used for measuring joint motion are illustrated.

The lack of uniformity in records, the great number of instruments used for measurement and the diversity of terms used in describing motion have caused much confusion. A system of measurement is therefore presented which defines the movements of nearly all the joints of the body, and an instrument that will measure joint motion accurately is described. Approximate normal ranges of motion for the joints discussed are also given. This system is based on the following: Measurements of movements made toward the head in the

anteroposterior planes will read toward o degrees; measurements of movements away from the head will read toward 180 degrees. In the lateral plane, measurements of movement toward the body will read toward o degrees and measurement of motion away from the body will read toward 180 degrees. All measurements will be made on the half circle scale from o to 180 degrees.

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ARRANGEMENT OF THE OPERATING ROOM

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ONE cannot approach the subject of motion economy in any field without careful planning of the work place, to the end that the principles of "work simplification" can be applied. The present operating room setup* demonstrates that there has been little if any change in the past thirty years, that is, during those years in which the science of motion study has developed. The arrangement of the instrument and supply tables, as shown in our survey, cannot be adapted to the fundamental principles of motion economy. An outstanding fault is to have the supply tables to the side or in back of the instrument nurse and not to have the tools always in front of the one handling them. Our micromotion studies have convinced us that a great number of awkward and inefficient motions are the direct result of this traditional setup.

The operating theater itself should be ample in size—there is a tendency toward making this room too small. We believe in having a separate room adjoining the operating theater for the administration of the anesthetic, in order that the patient may be moved into the already prepared work shop, rather than having the work shop assembled about the operating table. Naturally, advantage must be taken of the latest developments in the lighting field. Operating tables have certainly engaged the interest of surgeons, and this piece of surgical furniture has been brought to the highest degree of efficiency. While the operating table has received so much con-

siderations, the instrument and supply tables have been sadly neglected. Radical changes in these important facilities seem to be necessary to provide for: (a) prelocation of instruments and supplies within the normal grasping area; (b) the use of both hands; (c) the ability of the whole team to be at all times facing the field of operation; and (d) the fatigue factor.

Industry has found that the circular assembly setup answers these requirements. The tables described in our previous article[1] and used by us for the past year are making it possible to apply with increasing satisfaction the science of motion economy to our surgical work.

The division of the instrument and supply tables into two units is the crux of the whole problem. This dual arrangement encourages the use of both hands. It furnishes a place for the instruments and supplies which we see so often piled in disorder on the chest of a patient during laparotomy, where they too frequently slide off to the floor. In any surgical procedure, there should be "trays to the right of them, trays to the left of them."

We have been particularly interested in an article by W. H. Ogilvie.[2] We note that his plan of the field of work suggests some of the points touched on in this article. However, we are frank to criticize his arrangement of planned work. Certainly such a setup can in no way permit motion economy. Look at the reach for the dump for used materials. From his diagram itself, one can see that practically all of his work is done in the maximum grasping area, with no provision for two-handed activity. Mr. Ogilvie may be entirely satisfied with the right sided arrangement of his own

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* In the past year we have made a survey of 500 operating rooms throughout the United States, and they all depend upon the Mayo instrument stand, plus instrument and supply tables placed to the side or behind the instrument nurse.

tools, but is it always possible for him to secure a left handed assistant?

We believe that the two-table equal duty
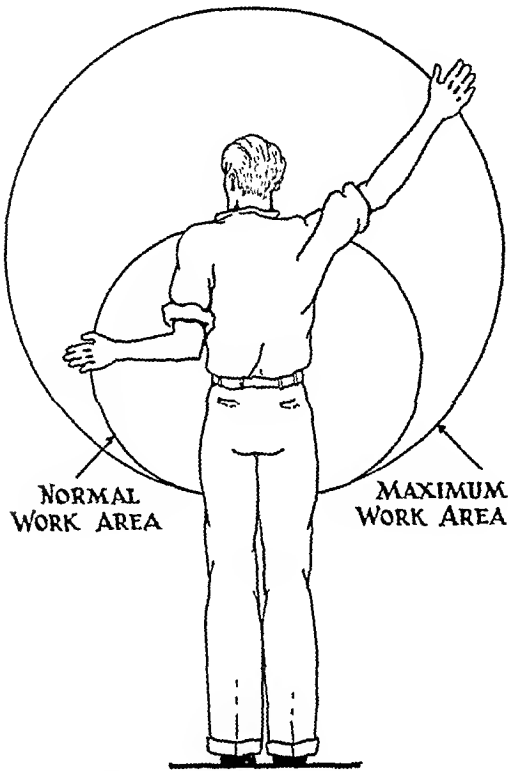
FIG. 1. Showing extent of normal work area as compared with maximum work area.

arrangement of instruments and supplies has value aside from these considerations. In the case of many hospitals, they answer a dual problem: the problem of the surgical training of undergraduate nurses and the necessity for a thoroughly experienced instrument nurse as an integral part of any operating team. While it is imperative for undergraduate nurses to have a period of training at the operating table, it is not safe for the patient nor satisfactory to the surgeon to have a student nurse, possibly her first experience in assisting, in sole charge of the armamentarium during an operation. Hospitals say they cannot afford always to have a graduate nurse scrubbed up. Economy should not interfere with an ironclad rule that no major operative procedure should be carried out unless a graduate instrument nurse is actually attending to the operation. With this two-table arrangement, the student nurse can

preside over one table and be watched over by the graduate presiding at the other table. The student can then watch and
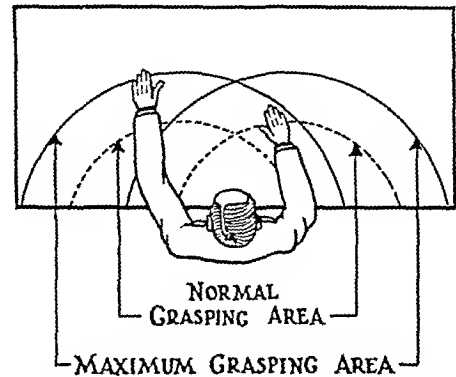
FIG. 2.—Normal and maximum grasping areas.

learn without being placed in a position of terrible responsibility without due preparation and experience.

The instrument and supply tables, the surgical work bench, consist of two similar units, one having narrower ends, due to the limited space between the ensiform cartilage and the neck, the location in which this table is generally used. In work on any part of the body, the major supplies are placed to the master hand of the surgeon, while lesser space is needed for his opposite hand. The tops are made in the arc which corresponds to the normal grasping area of a person standing or sitting in the center of the arc. There is a central pedestal and the leaves of the table extend over the operating table. A raising and lowering device permits adjustment to the proper height. It is desirable to have the instrument trays as nearly as possible at the same level as the wound. The table tops, extending over the patient, permit the placing of instruments and supplies thereon within the normal grasping area of both the surgeon and his first assistant. We have found it much more convenient to have the wash basin incorporated in the table itself, and this eliminates a piece of furniture.

Prelocation of instruments and supplies is essential to any progress in motion economy. Before starting an operation everything that is to be used should be placed in

a definite and fixed position. This will aid the surgical team in "habit formation," permitting development of automaticity. It cannot be emphasized too strongly that it is to the surgeon's advantage to be able to perform his operation with the least possible exertion. It certainly adds to strain to have the materials and tools scattered over the work place in a disorderly fashion, so that the surgeon must exert mental effort searching for the tool he needs. A place for everything and everything in its place saves time and effort. Arranging instruments and supplies properly enables the operator to perform his job in the proper sequence at a rapid pace and with a minimum of effort. Since the eye directs the hand in reaching for an object, the eye must be taken away from the operation itself. However, if the tools are prelocated in a definite place, and if they are always grasped at this definite point, the hand will automatically fall on the right instrument without the assistance of the eye.

Consideration must here be given to the order in which the instruments are to be used, to the end that the first used instrument, e.g. the knives, should be nearest to hand. Working outward from this point, the instruments should be placed in the sequence in which they are ordinarily needed. This prelocation of tools is to be used in the case of the commonly employed instruments, those used in the approach to the pathology, "the front line tools,"[2] such as knives, hemostats, scissors, thumb forceps and Kelly clamps. The less common instruments, those to be used at only one stage in the operation, or the multiple instruments[2] are kept in a definite prelocation by the instrument nurse along the line of her grasping area. It is for these instruments that we generally use manual signals, as they are passed directly from the instrument nurse to the hand of the surgeon or the first assistant. We have found that this results in greater time saving than having the instrument nurse pass all of the instruments.

The instruments should be prelocated within the normal grasping area. It will be noticed that the normal grasping area makes a circular arc about the body of the worker with the arms hanging loosely at the side. Thus a circular assembly setup is required if we are to avoid using the maximum grasping area, which in itself causes awkward and tiresome movements. Having tools in a straight line in front of the worker forces him to reach further and further outward to grasp them, this also running into the maximum grasping area.

In this rearranged operating room setup, we have been able to have the instruments and supplies used by the surgeon in his normal grasping area, and to apply the same principle to each member of the team, the first assistant surgeon and the instrument nurses. Each has his or her instruments and supplies within his or her individual grasping area and all are so coördinated that there is no occasion for anyone to have an extended reach or for twisting or turning the body about in carrying out activities. The handles of the instruments should be along the line which represents the arc of this grasping area. The handles should always be found in exactly the same position (the duty of the instrument nurse), and some device should be invented which will raise the handles above the level of the table. (We are working on this problem now.) The grasping of an instrument lying on a flat surface is more difficult than if the handle is elevated on the principles of the new type of desk pen, which enables one to pick up the pen in just the position in which it is to be used. We should be able to grasp instruments in the position in which we are to use them. This saves repositioning after grasp. In industry, this is called "prepositioning." Having the handles extend over the edge of the table is not satisfactory.

For the guidance of operating room supervisors, some method must be provided to enable them to have the instruments prelocated with exactness. This

Dotted Arcs Indicate
Approximate Normal
Grasping Areas.

Supply Nurse

1
SET-UP
for
HEAD and NECK

First
Assistant Surgeon

Supply Nurse

Surgeon

First
Assistant Surgeon

Instrument Nurse

Instrument Nurse

Surgeon

SET-UP
for
BREAST and THORAX
2

Supply Nurse

First
Assistant Surgeon

Instrument Nurse

Anesthetist

SET-UP
for
ABDOMEN
and
TRUNK
3

SOILED INSTRUMENTS

SOILED INSTRUMENTS

Surgeon

HAROLD C. THOMSON

FIG. 3. Operating room set-up: 1, for head and neck operations; 2, for breast and thorax operations; 3, for abdomen and trunk operations.

should imply possibly the use of photography or as has been suggested by Dr. Parry of Asbury Park, an x-ray negative showing

lazy hand to work, and we will have made progress toward two-hand consciousness. With the dual instrument tables, two-hand
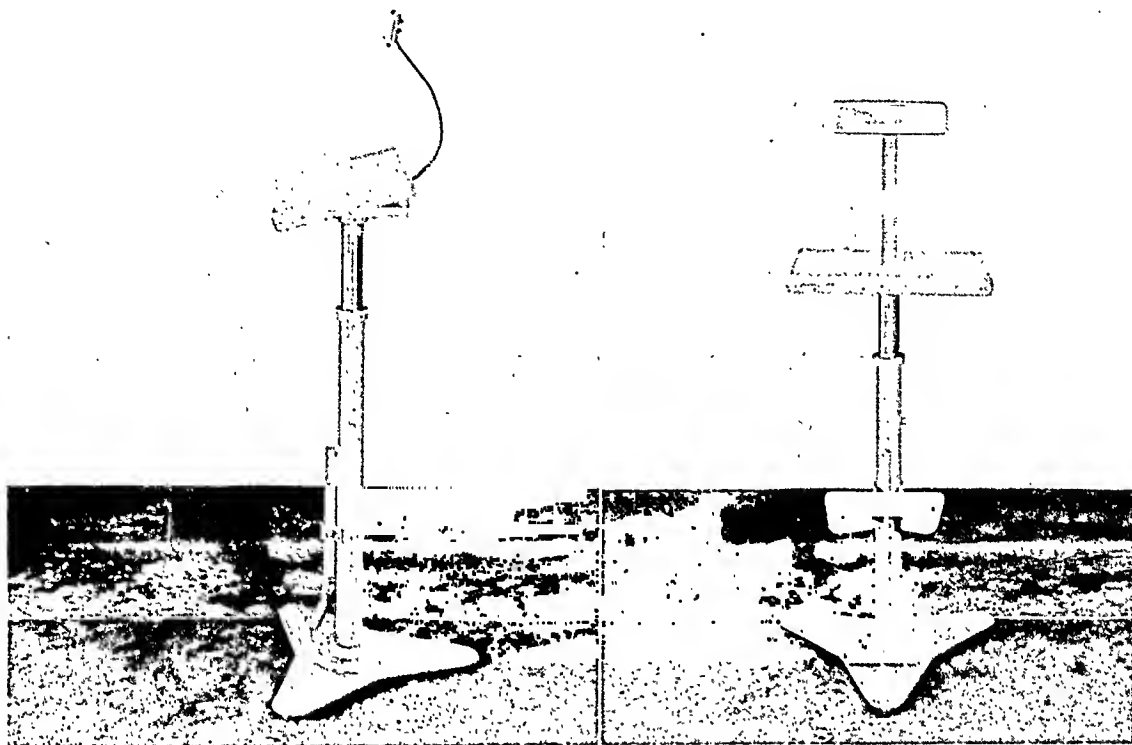
FIG. 4. Surgeon's stool.

FIG. 5. Nurse's stool.

the instruments in their proper position on the table.

A second principle of work simplification is the use of both hands profitably and synchronously. It is surprising to discover how many people have only one hand for doing things. The off hand does not seem to do much but hold. The use of both hands in this sense does not mean full ambidexterity, for it is a very simple matter to learn how to use hemostats, scissors and the like with either hand. Certainly if both hands are profitably engaged at the same time, it will not take as long to do a piece of work as with one hand working alone. It is much easier to develop rhythm if both hands are going through balanced movements at the same time, than if one hand is working by itself. Slow motion study of our movies proves this point very clearly. If we make an operation chart of both the right and left hands from such study, we can develop ways to get the

action is encouraged. If one finds an instrument or sponge ready to hand, it is natural to pick it up and make use of it with that hand. It certainly does not promote pleasing rhythm to reach across in front of the body to get something or to put something down. These motions involve both maximum reach and turning of the body. The dual setup described gives full play to the training of the off hand and in practical use we have derived much satisfaction from it.

An operation should have the continuous undivided attention of the whole operating team. It should not be necessary for any of them to turn around at all. We have a moving picture film taken of an operation with the common setup, which demonstrates that the surgeon could have seen the back of his chief instrument nurse eight times in seven minutes. As one studies these matters and becomes motion conscious, many of these defects can be detected by simple observation.

No work place gives out fully the principles of work simplification unless it meets the problems of fatigue. This fatigue factor has not received the consideration it merits. Too often have we seen exhausted operating teams. No member of the team can afford to be exhausted during a surgical maneuver. Operating room supervisors welcome the thought of lessening fatigue, footache and backache, in the case of their nurses. Careful planning can do much to ease this strain. The height of the operating table should be so placed as to be raised or lowered at will. Stools or rests of proper design should be provided to permit good posture and to allow the individual the choice of sitting or standing without turning away from the work place. Long continued standing or sitting is likewise exhausting, and the ability to change from the one position to the other is restful. So important is this, the ability to stand or sit, from the point of view of health, that some states have laws requiring that the work place be so arranged.

When high chairs or stools are used, they must be provided with a foot rest. The absence of a foot rest forces the worker to hook the heel of his shoe over a rung of the chair or let his feet dangle in the air. Either position is uncomfortable. We have devised chairs and stools to meet these special needs. The photographs give a general idea of the ones we are using. These stools and chairs are fitted with a device to raise or lower the seat. A spring arrangement in the pedestal, controlled by a foot lever, makes it possible to have the chair at the proper level. It does not require the services of another helper, nor does it involve any use of the sterilized hands. The back rest is similar to that used in the common stenographer's chair.

Seating of the operating team is only practical when the circular assembly setup is used as outlined, because here alone we eliminate the necessity for any maximum grasp or turning away from the field of operation. Let us increase our efficiency of thought and action by eliminating fatigue as much as possible.

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MALIGNANT TUMORS OF THE TESTICLE

A REVIEW OF EIGHTY-THREE CASES

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MALIGNANT tumors of the testicle are rather rare as compared with new growths in other parts of the body. Simpson[1] states that they constitute approximately 0.5 per cent of all malignant tumors in the male and only 0.063 per cent of all general·hospital admissions. MacKenzie[2] reports only twenty-seven cases of testicular tumors in 307,174 admissions at the Royal Victoria Hospital. At the Mayo Clinic the frequency is said to be one in 6,000 general admissions. The files of the Cleveland Clinic contain records of eighty-three cases of malignant tumors of the testicle. These include twenty-three cases previously reported by Higgins.[3]

The pathologic classification of tumors of the testis has always been a subject of controversy and still is in confusion. Langhans'[4] work in 1887 marked a distinct epoch in our knowledge of testicular tumors. He recognized microscopically the teratomatous and carcinomatous nature of these growths and classified them on a structural basis.

In 1911 Ewing,[5] after reviewing the literature and carefully studying a series of cases, concluded that all tumors of the testicle were of teratomatous nature. This conclusion was disputed by Chevassu[6] who believed that the majority of malignant tumors of the testicle were solid tumors arising from the epithelium of the seminiferous tubules, and he applied to them the term "seminome." Ewing[5] contended that the seminoma of Chevassu is not distinct from the malignant embryoma, but that it is an embryoma or teratoid tumor in which there is a one-sided cellular development resulting in a tumor made up of homologous cells with lymphoid stroma.

These two theories regarding the origin of malignant testicular tumors have prevailed; Ewing's theory has been upheld by Wilms,[7] Martland and O'Crowley,[8] Cairns,[9] and others, while Chevassu's theory has been supported by Eisendrath and Schultz,[10] Thalhimer and Geist,[11] and many others.

At the present time, the accepted classification seems to be the division of testicular neoplasms into the homologous and the heterologous types of tumor. The former are comprised mainly of the so-called pure monocellular seminomata and the sarcomata. The heterologous tumors are of two kinds: (1) the mixed tumors of adult tissue, the so-called organized embryomata, dermoid cysts, and adult teratomata; and (2) the embryonal tumors, a group composed of the chorionepitheliomata, embryonal adenocarcinomata, the sarcomatous mixed tumors, and the embryonal carcinomata, depending upon the predominance of trophoblastic, hypoblastic, mesoblastic, or epiblastic elements respectively.

Pathology: Most malignant tumors of the testicle may be classified into one of two groups: (1) teratomata or heterologous tumors, and (2) seminomata or homologous tumors.

Teratomata comprise the majority of the malignant tumors of the testicle. They are mixed tumors which contain the derivatives of the three germinal layers. Adami[12] best describes this growth by saying that it arises from a totipotent cell which has the power of giving rise to every order of cell in the body. An adult teratoma is one in which the tissues are fully differentiated and arrange themselves in an orderly fashion. These are not highly malignant, run a more

prolonged clinical course, and distant metastases are less frequent. They constitute only 5 to 10 per cent of all teratomata.

The embryonal teratoma, as the name implies, is one in which the tissues are less differentiated. The most common tumor in this group is the so-called embryonal carcinoma in which there is a predominance of the large, round, or polyhedral cells with a vesicular hyperchromatic nucleus. Grossly, it is soft, rapidly growing, and often shows areas of necrosis, hemorrhage, or suppuration. It is very malignant and metastasizes early. Usually the presence of heterologous elements indicates the teratomatous nature of the tumor; however, at times it is difficult to differentiate it from the homologous type.

The seminoma or spheroidal cell tumor is large, firm, pearly gray in color, and medullary in character. Microscopically it is composed of large spheroidal or ovoid cells with deeply staining nuclei and granular cytoplasm.

In the literature, great variation is found regarding the incidence of the different types of testicular tumors, this being largely due to various methods of classification employed by different authors. Of the eighty-three cases which we reviewed, eleven were reported as seminomata, forty-seven as teratomata of which twenty-seven were listed as embryonal carcinomata, eleven as sarcomata, and in fourteen cases the type was not specified. This grouping is in all probability somewhat inaccurate as the patients in this series were seen and treated over a period of the past thirty-five years and in the majority of the earlier cases we were unable to obtain a specimen or slide for rediagnosis. The low percentage of seminomata and the high incidence of sarcomata in this series is explainable, we believe, by the fact that many of the former were miscalled sarcomata, especially among the earlier cases.

Age Incidence. Malignant tumors of the testicle appear most frequently during the age of greatest sexual activity, that is, between the ages of 20 and 50 years,

although no age is exempt. In this series, 87.5 per cent of the cases occurred within this age limit. According to Kutzmann, Gibson and Perkins,[13] tumors of the testicle are of comparatively rare occurrence in children, and when they do occur it is chiefly in early infancy, usually during the first year of life. Roche[14] states that 84 per cent of testicular dermoids occur during the first year of life and according to Simpson[1] the greatest incidence of teratoma is between 20 and 30 years, while that of seminoma is between 30 and 40 years. Eisendrath and Schultz[10] analyzed nine cases of embryonal carcinoma in which the average age of the patients was 29 years, and six cases of seminoma in which the average age was 41 years. In our series (Table 1) the average age of the patients with seminoma was 39 years and of those with teratoma 34 years. The youngest patient in the group was 20 years of age and the oldest 64 years.

ETIOLOGY

The etiology of malignant tumors of the testicle, like that of all malignant tumors, remains unsolved. Most writers agree that heredity plays no part in this disease. In many cases the patient gives a history of trauma which some authors consider an important etiologic factor while others believe this frequently is merely the incident that causes the patient to note an enlargement of the testicle but that the enlargement was already present. The fact that trauma might initiate the growth cannot be denied but is difficult to prove. It is known that constant and prolonged irritation may promote the production of a malignant growth. The presence of a preëxisting tumor of the testicle cannot be excluded as a possible cause and such a tumor may be stimulated by trauma to more rapid growth. In Dean's[15] series, fourteen of the 124 patients, or 11 per cent, had observed the enlargement after trauma to the testicle. Kober[16] reports that 28 per cent of a series of 114 patients gave a history of previous trauma, Stelle[17] gives

13.3 per cent as the incidence of trauma in his series, and Rea,[18] reviewing seventy-six cases, reports that twenty-nine, or 38 per cent of his patients, had experienced definite trauma, three had hydrocele, and four coëxisting hernia. In our series sixteen, or 19.2 per cent, of the patients gave a history of trauma and in three of these the injury had occurred twenty years or more before the development of the tumor. Fifteen, or 18.1 per cent, of the patients had a hydrocele as well as a tumor, and three had a coëxisting hernia.

Testicular tumors are said to occur more frequently in undescended than in normally descended testicles. Simpson,[1] quoting Marshall, Hempel, and Howard, reported the incidence of cryptorchidism among 7,119,800 normal men to be 0.12 per cent. The War Department medical records for the World War lists 3.1 cases of ectopy for every 1,000 men examined. Hinman[19] collected 728 cases of testicular tumors variously reported and found that eighty-two, or 11.2 per cent, occurred in undescended testes. He also found that in 3,646 cases of undescended testes variously collected, there were only eight instances of malignancy. Odiorne and Simmons[20] report a series of fifty-four testicular tumors of which 11 per cent were incompletely descended and in Dean's[15] series of 124 cases, 13 per cent were cryptorchid. In our series of eighty-three cases, seven patients, or 8.43 per cent, had cryptorchidism. Thus the incidence of undescended testis among patients with testicular neoplasms appears to be thirty to one hundred times as great as that among normal individuals. This increased incidence is believed by many to be due to the fact that undescended testicles are more subject to repeated traumatism.

Reports in the literature vary as to the predominance of tumors in the right or left testicle but all agree that bilateral testicular tumors are quite rare. In Cunningham's[21] series, thirty-four of the tumors were found to involve the right testicle, twenty-five the left, and three were bi-

lateral. In Dean's[15] series 55 per cent involved the right testicle and 47 per cent the left. Rea[18] reports that the right testicle was involved thirty-four times and the left twenty-two times in his series. In our cases forty-nine involved the right side, twenty-nine the left, two cases were bilateral, and in three histories the side was not specified. In 1932 Peirson[22] collected from the literature forty-six cases of bilateral malignant tumors of the testis and added one additional case.

SYMPTOMS

There are no pathogonomic signs or symptoms of a malignant tumor of the testicle. The first symptom ordinarily noted is an increase in the size of the testicle, this usually being painless and accompanied by a feeling of weight or fullness in the scrotum. In 92 per cent of the 124 cases reported by Dean,[15] increase in the size of the testicle was the first sign. Loss of weight occurred less frequently but was present in 41 per cent of Young's[23] and 57 per cent of Dean's[15] cases. In 83 per cent of the cases in our series, enlargement of the testicle was the chief complaint. Pain and tenderness were present in many cases but were strikingly absent in others. In Tanner's[24] series, 52 per cent of the patients complained of pain, while among Dean's[15] cases only a few patients suffered from this symptom. Abdominal cramps, pain in the back, indigestion, anorexia, weakness, and respiratory symptoms are late manifestations and usually indicate the presence of metastases. The course of the disease is dependent upon the type of tumor and the extent of metastasis.

DIAGNOSIS

The rapid progress and unfavorable prognosis of most testicular tumors make early diagnosis imperative if satisfactory results are to be obtained.

A man between the ages of 20 and 50, presenting himself with a testicular enlargement with or without a history of previous trauma or infection, should be

examined with the possibility of malignant disease in mind. Inspection usually discloses unilateral enlargement of the scrotum without signs of inflammation. Generally there is no apparent retraction or shortening of the penis as is so frequently observed in hydrocele. The tumor cannot be visualized by transillumination unless some portion shows cystic degeneration.

As a rule, palpation reveals the testicle to be smooth, ovoid, and symmetrically enlarged. Occasionally, nodules or areas of softness may be felt. The tumor is freely movable within the scrotum and manipulation is not accompanied by pain. Large veins may cover the mass and be seen through the skin. The spermatic cord may be normal or in late cases may be enlarged and infiltrated by tumor tissue. The epididymitis is usually palpable and affords a valuable diagnostic aid, as one can then be certain that the enlargement involves the testis proper. However, at times it is flattened out and spread over the mass so that it cannot be made out.

In making a differential diagnosis, gumma, tuberculosis, hydrocele, hematocele, and orchitis must be considered.

A gumma more nearly simulates tumor than any other testicular lesion. Careful questioning may elicit the history of a primary luetic lesion, but a determination of the Wassermann reaction should be made in all cases of testicular enlargement. If doubt still exists as to the character of the tumor, the administration of antiluetic therapy for one or two weeks will usually suffice to differentiate the conditions. It should be borne in mind, however, that lues and a malignant tumor of the testicle may coëxist, so undue dependence must not be placed upon a positive Wassermann reaction in a case in which the tumor does not respond to antiluetic therapy. In one of our cases a swelling of the right testicle developed in a 34 year old man who was known to have lues. This did not decrease in size following antiluetic therapy. The pathologic diagnosis of the tissue removed

at operation was embryonal carcinoma. Metastasis later developed to the retroperitoneal lymph nodes on the right side.

A careful investigation into the personal and familial histories of the patient may often be of value in determining whether the condition is due to tuberculosis. In a tuberculous infection, the epididymis is the primary seat of the disease and only in very late stages is the testis proper involved. The epididymis is nodular, the vas deferens frequently bead-like, and the seminal vesicles and prostate are often involved. If the lesion extends to the skin of the scrotum, ulceration and persistent sinus formation usually follow. A roentgenogram of the lungs may also demonstrate the presence of an active or latent tuberculous lesion there. As for the clinical course of tuberculosis, it may be more rapid than that of a malignant growth, pain is more frequently present, and an elevation of temperature may be noted.

It must be borne in mind that a hydrocele and a malignant tumor of the testicle may coexist. This combination of diseases was found in 15 or 18.1 per cent of the cases in our series. Transillumination should always be employed in making a diagnosis of hydrocele. Because of the frequent coexistence of these conditions, all hydroceles should be aspirated and the testicle carefully palpated after the tapping to determine the presence or absence of a tumor.

In the differential diagnosis between hematocele and tumor of the testicle, it is important to learn whether there is a history of trauma. The swelling of a hematocele is usually uniform and firm, and seldom is one able to transilluminate the scrotum or to produce fluctuation. Cunningham[25] states that "needle puncture in suspected hematocele is useless and dangerous; blood need not come from a hematocele, and the needle point may disseminate new growth." One's diagnostic ability may be taxed to the utmost to differentiate a hematocele of long duration in which solidification has taken place from

a malignant tumor of the testicle. Tanner[24] states that the "tunica vaginalis can be palpated on the surface of a scrotal tumor and that is not true in hematocele, in which also the epididymis cannot be felt between the fingers, as it is hidden within the hematocele."

In orchitis there is often a history of recent trauma and physical examination usually reveals a painful, inflamed, swollen testicle.

Diagnostic methods of the past, which have been largely a process of elimination, have led to many incorrect conclusions. In many other instances, uncertainty of diagnosis in neoplastic disease of the testis has resulted in the loss of valuable time before the institution of treatment. Since the discovery that sex hormone of the anterior hypophysis is present in the urine of patients with malignant testicular tumors, a correct diagnosis may be made more promptly. The appearance of this sex hormone of the anterior hypophysis or prolan A in patients with malignant testicular tumors was first observed by Zondek[26] in 1929. Ferguson[27] states that prolan A is not found in the urine of a normal, healthy man. He believes that the hormone disappears from the urine within seven to ten days after birth and does not again reappear except when some pathology is present. Branch[28] examined the urine of 500 men and found that no hormone was present except in two cases of teratoma of the testis. However, Katzman and Doisy[29] have stated that a small amount of prolan A is found in the urine of normal men between puberty and the climacteric but in a quantity very much smaller than that in the urine of patients suffering from teratomata.

Ferguson[30] has studied in great detail the excretion of this gonadotropic hormone in men with malignant testicular tumors, using in all his investigations a quantitative method of determining the presence of the hormone. He studied 100 cases of benign lesions of the testis and in no case was the excretion of prolan A more than 100 mouse

units per liter of urine. He then studied 117 cases of untreated teratoid tumors, except the adult cystic types, and in each case there was an excretion of prolan A in excess of 500 mouse units per liter of urine. In another article Ferguson[31] reports the following findings, after carrying out a quantitative hormone determination in 37 cases of testicular tumors:

Structure	Cases	Limits of Initial Excretion of Prolan A in Mouse Units per Liter of Urine
Embryonal adenocarcinoma....	7	10,000–40,000
Embryonal carcinoma with lymphoid stroma...........	15	2,000–10,000
Seminoma...................	10	400–2,000
Adult teratoma...............	5	50–500

Ferguson[27] concludes that the hormone output increases in proportion to the embryonal character of the tumor and decreases as the tumor approaches the adult type. He also states that the excretion of prolan A increases as metastases become more extensive.

Hinman[32] states that his experience with the hormone tests seems to show that neither the sarcomata nor the pure monocellular seminomata cause the excretion of a gonadotropic hormone. In our series, a qualitative Friedman test was carried out on four of the patients seen recently. Two tests gave definitely positive reactions, one being in a case of embryonal carcinoma and the other in a case of bilateral reticulum cell sarcoma. A third test which was performed on a patient with a well differentiated teratoma gave entirely negative results, while the fourth test on a man with a seminoma was reported negative, but showed three plus congestion of the uterus and one plus swelling of the uterus. The diagnosis in each case was confirmed by a careful study of the pathologic specimen.

It was anticipated that the tumor which caused the excretion of the greatest amount

of prolan A would be most sensitive to irradiation but this has not proved to be true. However, a quantitative estimation of this hormone does afford a method of determining the radiosensitivity of a testicular tumor. The method of doing this is stated by Henline[33] as follows: "The original amount of prolan A exereted is first determined. The tumor, groin, and lower abdomen are then exposed to a full skin erythema dose of high voltage x-ray. If, following this treatment, the hormone output drops sharply, one may conelude that the tumor is radiosensitive and the prognosis is more favorable."

Ferguson[30] states that the hormone is absent in the urine as early as seven days after an operation for testicular tumor providing all tumor tissue has been removed. He also noted that in reeurrent eases there was an increased output of prolan A in the urine from two weeks to two months before the reeurrenees eould be demonstrated clinically.

The absenee of pain in the early stages of the tumor is unfortunate. Patients usually eonsult a physieian for pain; henee patients with tumors of the testiele often fail to seek medical advice until months after the onset of the tumorous growth or until they are annoyed by other symptoms produeed by metastatic lesions. In our series, the average length of time which elapsed between the discovery of the swelling of the testiele and the medical eonsultation was 16.7 months, the shortest duration of symptoms being one month, and the longest five years. Dean,[15] in his series of 124 eases, found the average duration of symptoms before a physician was consulted to be eighteen months and in 45 per cent, the duration was more than one year.

In many cases, clinical evidence of metastasis is present before treatment is sought. Among the eighty-three cases included in our series, twenty-seven or 32.5 per cent showed clinical evidence of metastasis when first seen. Dean[34] reports sixty-three cases in 49 per cent of which metastatic lesions were present when the patient was first examined. In 84 per cent the metastases had oeeurred to the spermatie cord and lumbar nodes and in 16 per eent to the lungs. Metastasis often oeeurs quite early in the disease and may take plaee by either one or both of two routes, (1) the lymphaties or (2) the blood vessels. Simons[35] states that there is no superfieial lymphatic route from the testiele to the superfieial inguinal glands; thus metastasis does not oeeur to these glands unless the skin of the serotum is involved.

The lymphatics of the testicle are numerous and eommence ehiefly in the lymph spaees between the seminiferous tubules. According to the work of Jamieson and Dobson,[36] the lymphatics of the testiele unite with the lymphaties of the epididymis and follow the spermatic eord to the ureter and then enter the primary lumbar nodes surrounding the aorta and vena cava. These glands extend from the beginning of the common iliac artery to the renal vessels. The eommonest primary distribution for the right side is between the aorta and vena cava and upon the aorta, and for the left, upon and along the side of the aorta. From these are involved the secondary glands which eonsist of the primary glands of the opposite side and the glands above the renal vessels as well as those behind the great vessels and along the outer side of the eommon iliae artery. Ferguson[31] showed that, in as many as 90 per eent of normal individuals, at least one lymph ehannel can be demonstrated ascending above the renal vessels and eonneeting with the mediastinal chain of nodes.

According to Gray's Anatomy[37] the internal spermatic artery, a branch of the abdominal aorta, accompanies the spermatic cord along the inguinal canal and through the subcutaneous inguinal ring into the scrotum. It then descends to the testis, giving off branches to the epididymis. The spermatic veins emerge from the back of the testis and after receiving branches from the epididymis unite to form the plexus pampiniformis

which constitutes the chief mass of the cord. They ascend along the cord and finally unite to form a single vein which on the right side opens into the inferior vena cava and on the left side into the left renal vein. According to MacKenzie and Ratner,[2] invasion of the veins by continuous growth has been observed even as far as the heart.

Wells[38] states that, in nearly all cases, metastasis occurs to the lumbar glands on

TABLE I
AGE INCIDENCE

Years	Number of Cases
20–29	23
30–39	31
40–49	16
50–59	6
60–69	4
Not stated	3
Total	83

the affected side first, then to the mediastinum, and early enter the blood stream to become widely disseminated. In Dean's[15] cases 69 per cent of the lesions metastasized to the abdominal retroperitoneal lymph glands on the side of the abdomen corresponding with the side of the original tumor, 9 per cent to the glands of the left supraclavicular fossa, 8 per cent to the lungs, 7 per cent to the liver, and 1 per cent to the kidney.

In our series, metastases were found primarily or developed later in the abdominal cavity in 51 per cent of the cases and in 60 per cent of these it was specified being on the same side as the site of the original tumor. Fifteen per cent metastasized to the glands in the supraclavicular region, 13.8 per cent to the lungs, 10.8 per cent to bones, 5 per cent to the liver, 3 per cent to the mediastinum, 2.3 per cent to the brain, 1 per cent to the stomach, and 1 per cent to the colon. A local recurrence with involvement of the inguinal glands was noted in 4.8 per cent of the cases.

TREATMENT

Many types of treatment for malignant growths of the testicle have been advo-

cated. Orchidectomy alone is the oldest form of treatment while different authors have suggested the following methods as a means of producing more lasting cures but without great success: orchidectomy followed by x-ray, radium pack, or Coley's serum; orchidectomy followed by a radical resection of the lymph glands; x-ray alone; and radium alone.

Orchidectomy is the simplest and most widely used surgical procedure. Hinman[32]

TABLE II
RESULTS IN SEVEN CASES WITH CLINICAL EVIDENCE OF METASTASIS TREATED BY SIMPLE ORCHIDECTOMY

Type of Tumor No. of Cases	Years Followed								
	1			2			3		
	*A.	D.	L.	A.	D.	L.	A.	D.	L.
Teratoma 2	1	1	0	0	2	0	0	2	0
Embryonal Ca. 1	0	1	0	0	1	0	0	1	0
Sarcoma 2	0	2	0	0	2	0	0	2	0
† Clin. Malignant 2	2	0	0	2	0	0	0	2	0
Total—7	3	4	0	2	5	0	0	7	0

* A. —Number of patients living.
  D.—Number of patients dead.
  L.—Number of patients lost in follow-up.
† Clinically malignant—no pathologic diagnosis recorded.

has been a strong supporter of the radical operation, believing that this procedure, like castration, must be done early if done at all. He states that "if the radical operation is of use at all it should be used on all patients without clinical evidence of metastases in whom a malignant tumor is proved after castration. When metastases are palpable, the operation is impractical since a clean, complete removal of the lymph nodes in all probability will be impossible."

The operation is done in two stages. The first step consists of a simple orchidectomy

after the cord has been dissected free and divided high in the inguinal canal. This is done to prevent general metastasis from the squeezing of the tumor cells into the blood stream. The second stage attempts the removal of all the lymphatics of the general distribution of the right and left primary and immediate secondary groups. This generalized area has been clearly determined by Hinman[12] as follows: "It may be bounded by an imaginary trans-

clinical purposes they may be classed as radiosensitive or radioresistant. It is fairly well established that the seminomata are radiosensitive while the teratomata are radioresistant. However, it is advisable to check the radiosensitivity in each case by the method outlined above. Healine[22] believes that in the case of a radiosensitive tumor without demonstrable metastasis, an orchidectomy should be done, followed by further irradiation for metastasis as

TABLE III

RESULTS IN TEN CASES WITH CLINICAL EVIDENCE OF METASTASES TREATED BY SIMPLE ORCHIDECTOMY AND POSTOPERATIVE X-RAY THERAPY

Type of Tumor, No. of Cases	Years Followed																				
	1			2			3			4			5			7			10		
	*A. D. L.			A. D. L.			A. D. L.			A. D. L.			A. D. L.			A. D. L.			A. D. L.		
Teratoma 2	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0
Embryonal Ca. 2	2	0	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0
Seminoma 3	0	3	0	0	3	0	0	3	0	0	3	0	0	3	0	0	3	0	0	3	0
Sarcoma 3	2	1	0	2	1	0	1	2	0	1	2	0	0	3	0	0	3	0	0	3	0
Total 10	4	6	0	2	8	0	1	9	0	1	9	0	0	10	0	0	10	0	0	10	0

* A.—Number of patients living.
D.—Number of patients dead.
L.—Number of patients lost in follow-up.

verse line from 1–2 cm. above the renal pedicle, by vertical lines extending from this point on each side just outside the vena cava on the right, and from 1–2 cm. outside the aorta on the left to the level of their bifurcation, and follow along the iliac vessels to cross at the upper third of each external iliac and follow these vessels back to about 1 cm. below the bifurcation." This second stage should never be attempted until confirmation of the diagnosis has been made by an expert pathologist.

The part played by x-ray in the treatment of malignant tumors of the testicle depends upon their radiosensitivity, and for

indicated by the hormone tests. He advises the radical operation for a radioresistant tumor without evidence of metastasis but, if present, palliative treatment with radium packs or high voltage x-ray may be used. The prognosis, however, is very poor.

Coley[21] advocated and used his streptococcus and bacillus prodigiosus toxin in a series of cases in the belief that the serum has an inhibitory action on the growth of the tumor cells. He recommends orchidectomy first, followed by the intramuscular injection of graded doses of the toxin. He also advises massive doses of irradiation to the abdomen and supraclavicular regions.

Every patient, regardless of the treatment instituted, should be closely followed by repeated quantitative determinations of prolan A in the urine as an index of the progress of the disease.

Prognosis. Whatever type of treatment is employed, whether surgical or x-ray, the

TABLE IV
RESULTS IN SEVEN CASES WITH CLINICAL EVIDENCE OF METASTASIS TREATED BY IRRADIATION

Type of Tumor No. of Cases	Years Followed				
	1	2	3	4	5
	*A. D. L.	A. D. L.	A. D. L.	A. D. L.	A. D. L.
Teratoma 2	1 1 0	1 1 0	0 2 0	0 2 0	0 2 0
Embryonal Ca. 1	0 1 0	0 1 0	0 1 0	0 1 0	0 1 0
†Clin. Malignant 4	1 3 0	1 3 0	1 3 0	1 3 0	0 4 0
Total—7	2 5 0	2 5 0	1 6 0	1 6 0	0 7 0

* A.—Number of patients living.
    D.—Number of patients dead.
    L.—Number of patients lost in follow-up.
† Clinically malignant—no pathologic diagnosis recorded.

prognosis in cases of malignant tumors of the testicle is grave; however, the outlook for the patient with a radiosensitive tumor is much brighter than that of one with a radioresistant growth. Tanner[24] believes the prognosis is influenced by the pathology of the tumor, mixed tumors being more malignant than the so-called carcinomatous ones.

Operative Mortality. The operative mortality for orchidectomy is almost nil while that for the radical operation varies up to 12 or 15 per cent. Roche[14] believes that the radical operation is not justifiable, due to its great risk and high operative mortality.

Results of Treatment. After reviewing the literature as well as our own series of cases, we find the end results of treatment in cases of malignant tumors of the testicle are quite discouraging. Tanner[24] collected 600 cases from the literature in which the postoperative course had been followed in

465. Of these, 377, or 81 per cent, were dead and twenty-five, or 5.5 per cent, were alive and apparently well four years after operation.

Hinman[40] collected a series of 258 cases in which treatment was simple orchidectomy with or without x-ray therapy. Of

TABLE V
RESULTS IN THREE CASES WITH CLINICAL EVIDENCE OF METASTASIS IN WHICH NO TREATMENT WAS INSTITUTED

Type of Tumor No. of Cases	Years Followed
	1
	*A. D. L.
Seminoma 1	0 1 0
Sarcoma 1	0 1 0
† Clinically Malignant 1	0 1 0
Total—3	0 3 0

* A.—Number of patients living.
    D.—Number of patients dead.
    L.—Number of patients lost in follow-up.
† Clinically malignant—no pathologic diagnosis recorded.

these, 118 patients or 45.8 per cent were dead and 124 were living, but only seventeen, or 6 per cent, had survived for five or more years. Young[23] reported the cases of twenty-five patients who had been treated by orchidectomy. Of these, seventeen were dead and eight living. Eleven, or 61 per cent, lived only one year or less after operation, and of the eight living three had regional metastases and three had lived four years or longer.

Hinman[40] has been a staunch supporter for the radical operation. In 1933 he reported the results in eighty cases including nine of his own, in none of which was there any clinical evidence of metastasis at the time of the operation. Of this series 35 per cent had died from metastases.

Sixteen were living less than five years and seventeen, or 20.4 per cent, were alive and well five years or longer. Recently Hinman[32] has reported the results of treatment in a series of fifty-four cases, in twenty-five of which there was no clinical evidence of metastasis when the patient

74.6 per cent, were reported as being inoperable on admission.

Coley[24] reports good results in the treatment of neoplasms of the testicle by a combination of orchidectomy and Coley's serum. In a series of sixteen patients, eleven, or 68.7 per cent, lived more than

TABLE VI

RESULTS IN TWENTY-FIVE CASES WITHOUT CLINICAL EVIDENCE OF METASTASIS TREATED BY SIMPLE ORCHIDECTOMY

Type of Tumor, No. of Cases.	Years Followed						
	1	2	3	4	5	7	10
	*A. D. L.	A. D. L.	A. D. L.	A. D. L.	A. D. L.	A. D. L.	A. D. L.
Teratoma 5	5 0 0	5 0 0	3 2 0	2 2 1	2 2 1	1 3 1	1 3 1
Embryonal Ca. 11	7 4 0	5 6 0	4 7 0	4 7 1	2 8 1	2 8 1	1 8 2
Seminoma 3	2 1 0	2 1 0	1 2 0	1 2 0	1 2 0	1 2 0	1 2 0
Sarcoma 2	1 1 0	1 1 0	1 1 0	1 1 0	1 1 0	1 1 0	0 2 0
†Clinically Malignant 4	1 1 2	1 1 2	0 2 2	0 2 2	0 2 2	0 2 2	0 2 2
Total 25	16 7 2	14 9 2	9 14 2	7 14 2	5 15 2	5 16 3	3 17 5

* A. — Number of patients living.
   D. — Number of patients dead.
   L. — Number of patients lost in follow-up.
† Clinically malignant —no pathologic diagnosis recorded.

was first seen. Of this latter group, fourteen had the radical operation and ten are living, all with a good prognosis. The remaining eleven patients without evidence of metastasis were treated by castration and x-ray therapy. In this group, eight are living, only one with a good prognosis, four with a fair prognosis, and three with a definitely poor prognosis. Of the twenty-nine patients with clinical evidence of metastasis only nine are alive.

Dean[31] cites a series of 154 cases treated by x-ray and radium. Of these, forty-four patients, or 29.2 per cent, are alive without evidence of metastasis five years after treatment was begun. Of this group, 115, or

four years and six, or 37.5 per cent, lived more than ten years. However, this form of treatment has been less successful in the hands of other men.

In our series of eighty-three patients, there were seventeen, or 20.4 per cent, five year survivals for the entire group. As previously mentioned, fifty-six of the patients were reported as being free from any clinical evidence of metastasis when first seen, and all the patients living at the end of five years fell in this category, giving a 30.35 per cent five year survival for this sub-group. None of the patients with clinical evidence of metastasis at the time of the first examination lived five years. We

further classified the patients according to the type of treatment instituted and Tables II to VII give the result of this study.

The foregoing follow-up study clearly shows that in those patients in whom clinical evidence of metastasis is demonstrable at the time of the initial examination, the prognosis is extremely poor.

surviving ten years were found to be enjoying good health and were free from clinical evidence of metastases, whereas eight, or 47 per cent, of the five year group had metastatic lesions with a poor prognosis. In 89.6 per cent of those known to be dead, the cause of death was attributed directly to the testicular malignancy.

TABLE VII

RESULTS IN THIRTY-ONE CASES WITHOUT CLINICAL EVIDENCE OF METASTASIS TREATED BY SIMPLE ORCHIDECTOMY AND POSTOPERATIVE X-RAY THERAPY

Type of Tumor. No. of Cases	Years Followed																				
	1			2			3			4			5			7			10		
	*A.	D.	L.	A.	D.	L.	A.	D.	L.	A.	D.	L.	A.	D.	L.	A.	D.	L.	A.	D.	L.
Teratoma 9	9	0	0	4	4	1	3	5	1	2	6	1	2	6	1	2	6	1	0	6	3
Embryonal Ca. 12	11	1	0	9	2	1	9	2	1	7	4	1	6	5	1	3	5	4	1	5	6
Seminoma 4	4	0	0	2	1	1	2	1	1	1	2	1	1	2	1	1	2	1	0	3	1
Sarcoma 3	3	0	0	3	0	0	3	0	0	3	0	0	1	1	1	0	1	2	0	1	2
†Clinically Malignant 3	2	1	0	2	1	0	2	1	0	2	1	0	1	2	0	1	2	0	1	2	0
Total—31	29	2	0	20	8	3	19	9	3	15	13	3	11	16	4	7	16	8	2	17	12

* A.—Number of patients living.
 D.—Number of patients dead.
 L.—Number of patients lost in follow-up.
† Clinically malignant—no pathologic diagnosis recorded.

(Tables II, III, IV and V.) In this group only two patients were alive four years after treatment; 52 per cent died within the first year, and 80 per cent were dead by the end of the second follow-up year. It is interesting to note that both the patients who survived four years had received x-ray therapy.

In the other group in which there was no demonstrable metastasis at the time of treatment, the results are somewhat more encouraging. Among these patients, there were seventeen, or 30.35 per cent, five year survivals and five, or 9 per cent, were living at the end of ten years. All the patients

When comparing the results obtained after simple orchidectomy alone and after orchidectomy plus x-ray therapy, there was a distinct margin in favor of the latter at the five year period, the comparison being 24 per cent five year survivals for the first group and 35.5 per cent five year survivals for the second. However, the percentages of patients with metastatic lesions were approximately the same, being 49 per cent and 46 per cent respectively. Furthermore, by the tenth follow-up year, there was no appreciable difference in the results, suggesting that the x-ray therapy merely slowed up the growth of the tumor and was

not curative. Dr. Portmann states, however, that in this series the patients who were given Roentgen therapy include only a few who were irradiated immediately prior to or after operation, the majority having been treated after metastases developed. In addition, many had treatment during the years when only very meager intensities of radiation could be given as compared with modern methods which unquestionably will give improvement in the results.

SUMMARY

1. Malignant tumors of the testicle are comparatively rare.

2. They may be divided into the homologous and heterologous types of tumor. The former is comprised mainly of the sarcomata and seminomata, the latter consisting of the mixed tumors of adult and embryonal tissue.

3. Testicular tumors occur most frequently between the ages of 20 and 50.

4. The etiology remains unsolved. There was a history of previous trauma in 19.4 per cent of the cases in this series.

5. The incidence of testicular tumors is higher in cryptorchids than in normal individuals.

6. Bilateral testicular tumors are rare. Neoplastic disease seems to involve the right testicle more often than the left.

7. There are no pathognomonic signs, painless swelling of the testis being the first symptom in the vast majority of cases.

8. Gumma, tuberculosis, hydrocele, hematocele, and orchitis must be considered in the differential diagnosis.

9. The hormone test for prolan A is valuable in diagnosis, prognosis, and treatment.

10. Metastasis takes place by way of two routes, namely: lymphatic extension and blood stream dissemination. The majority of lesions metastasize first to the retroperitoneal lymph nodes. The lungs and supraclavicular glands are also frequent sites of metastases.

11. Simple castration, castration followed by x-ray or radium, radical operation, Coley's serum, and x-ray or radium alone are the usual types of treatment.

12. Results of treatment are discouraging. The best results are obtained in cases without clinical evidence of metastasis. In our series a combination of castration and x-ray seemed to give the longest survival. In Hinman's hands, the radical operation in selected cases gives comparatively good results. Dean also reports good results with radiation therapy alone.

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LYMPHOGRANULOMA VENEREUM IN THE FEMALE

A CLINICAL STUDY OF NINETY-SIX CONSECUTIVE CASES

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LYMPHOGRANULOMA venereum is a venereal infection of virus origin with a remarkable predilection for lymphatic structures. The disease manifests itself by a primary evanescent genital lesion and subsequently by one or more subacute to chronic secondary localizing lesions. These are inguinal buboes, genital elephantiasis, rectal stricture and warty papillary excrescences or polypoid growths about anus, vulva, urethra and in the rectum and vagina. Ulceration commonly occurs either as a continuation and extension of the primary lesion or as a sequel to lymph stasis. Rectovaginal fistulae and ischiorectal abscesses are occasionally observed. Frequently systemic reactions occur.

Etiology. Lymphogranuloma venereum is due to a filtrable virus, immunologic response to which is shown by the Frei test. This test, when positive, remains so throughout life. It is a venereal disease which affects all races but in America is predominately found in the colored race. In our locality more white males are affected than white females. The highest incidence occurs during the most active period of sex life. The incubation period is inconstant and varies greatly. The primary lesion usually occurs ten to fourteen days after exposure and the adenitis twenty-one to thirty days. In an 11 year old girl with a history of a forced coitus (rape) the bubo appeared one month later. Twelve to forty days and longer may elapse from the time of the primary lesion before a positive Frei test is obtained.

In our series of cases there were ninety-two colored and four white females. Three of the white women, aged 26, 27 and 28 respectively, were married. One husband was tested with Frei antigen and reacted positively. The other white female, aged 20, was unmarried. Salpingitis was a complication in this patient. The colored women ranged in age from 11 to 56, nineteen being 20 or less and thirty-four from 21 to 30.

There is a high incidence to other venereal diseases in this group of patients. Twenty-seven either had active chancroid lesions or were positive to the intradermal chancroid test. Fifty-five either had a positive serologic test for syphilis or had been under treatment for this disease. Lesions of granuloma inguinale (diagnosed by finding Donovan bodies in smear or in tissue section) occurred in seven of this series. Three colored women had all four of the above venereal diseases and may have had gonorrhea in addition, inasmuch as no note of latent gonorrhea was made in this study. A considerable number have had salpingitis and several had been operated upon for this condition.

The time of appearance of the initial lesion according to the months of the year, where it was possible to determine, is recorded as follows:

January...................... 5
February...................... 1
March........................ 3
April......................... 3
May.......................... 2
June.......................... 1
July.......................... 2
August....................... 4
September.................... 4
October...................... 2
November.................... 1
December.................... 2

Clinical Manifestations. Usually within two or three weeks after exposure a primary, often transitory, papule or vesicle may develop. This may quickly heal and the patient rarely connects it with the later manifestations which occur within a few weeks. Fever, joint pains and malaise are frequent systemic reactions accompanying unilateral or bilateral inguinal adenitis. Because this disease attacks the lymph channels and glands there may result localized elephantiasis of the vulvar region, labia and clitoris, or production of nodular tags of tissue about the anus or urethra, leading to the various inguinal, urethral or anal syndromes. Some of these lesions may ulcerate, become secondarily infected and heal with difficulty. The ulcers may excavate, especially when combined with other infections as chancroid, syphilis, fusospirochetosis, or secondary infection by other organisms. All manifestations may occur with or without fever which may be remittent and sometimes chronic.

Types. Genital. This is characterized by blockage of the lymph channels with resulting chronic edema and ultimate ulceration of the skin. There is a tendency to formation of elephantiasis of the labia, especially the labia majora, and of the clitoris. Deep, suppurating subcutaneous abscesses may develop. These may rupture through the skin and cause persistent fistulous tracts. Healing and scar tissue occasionally result in stricture or fistula of the vagina. In this series there were thirty-five ulcerative lesions located as follows: vulva 18; vagina 14; cervix 5; anus 2; buttocks 2. Elephantiasis occurred

in twenty-three patients and in the following structures: vulva, either one or both labia majora, 20; clitoris 5. Seven of the above patients had both ulceration and elephantiasis. There was one stricture of the vagina.

Inguinal Adenitis and Buboes. Possibly due to the difference in lymph drainage, this is less common in the female than in the male. Nevertheless it occurs quite frequently, producing unilateral or bilateral adenitis with definite tendency to focal softening and subsequent drainage through multiple fistulous tracts. Twenty-nine of these patients had buboes and four had a history of buboes. The location of the bubo or buboes was about equally divided among the three possibilities, right, left and bilateral. In two patients with buboes in whom both the Frei and chancroid tests were positive, the Ducrey bacillus was isolated from the aspirated pus in pure cultures.

Anorectal Syndrome. This may be a subacute proctitis with redness, swelling and discharge from the mucosa. It may be chronic with resultant benign fusiform stricture of the rectum as though a rubber band of varying width were tightly wrapped around the rectal mucosa. This stricture, although it may be narrow longitudinally, is usually fusiform and regular in outline. It begins almost abruptly from a few centimeters to 8 to 10 cm. above the anus and extends upward a variable distance, sometimes to a length of 10 cm. In the early cases the constriction readily admits a finger but in the later ones hardly a knitting needle. While it is not strictly elastic, moderate dilatation is possible in the early stage. All patients with rectal strictures not due to trauma of hemorrhoidectomy, have had a positive Frei test. In addition to the stricture there is a definite tendency for verrucous tags of epithelium to develop at the anal orifice. Rectal strictures occur commonly in the female, possibly because of the relationship of the posterior vaginal wall to the rectum. This condition occurred in twenty-two

patients, i.e., about 23 per cent of the cases. In eleven patients it was uncomplicated. It was associated with elephantiasis

unnecessary. Anal tags were present in eight cases.

Urethral Syndrome. In some cases there

FIG. 1. Lymphogranuloma venereum—inguinal syndrome. Note the typical multinodular type of bubo.
FIG. 2. Lymphogranuloma venereum—genital syndrome. Note the elephantiasis of the vulva.

of the vulva in one patient; with vulvar ulceration in one; with urethral syndrome in one; with history of bubo in three; with previous colostomy in three; and with carcinoma of the anus in one. In the last two years the strictures have been gently dilated once a week with the gloved fingers. Colostomies have thus far been

is a tendency to development of papillary elevations of mucosa about the urethral meatus with inclination to loss of sphincter action. The accompanying symptoms, which are often intractable, are dysuria, frequency, and later incontinence, and in this series it was noted that there was a tendency to ulceration about the meatus.

We have never observed a urethral stricture in any of our patients. Six patients presented the urethral syndrome; all were complicated except one. Most of them were in association with vulvar lesions and one with rectal stricture.

Diagnosis. In the earliest manifestation of the initial lesion a nigrosine or dark-field study is necessary to eliminate syphilis. A smear study should be made for Ducrey bacilli to differentiate, if possible, chancroidal infection. The adenitis and bubo must be distinguished from those of chancroid, syphilis, gonorrhea (rare) and from the early inguinal lesion of granuloma inguinale (venereum) as well as from inguinal tumors, herniae, hydroceles, etc. The vulvar lesions may be simulated by granuloma inguinale, chancroidal infection, syphilitic lesions, tuberculous ulcers, or by epithelioma. In the tropics it is also necessary to differentiate the elephantiasis from that due to filaria Bancrofti. The urethral syndrome may be initiated by a urethral discharge which may be mistaken for that due to gonorrhea. The rectal stricture must be distinguished from that due to malignancy or to trauma of operative procedures. The anal tags may simulate hemorrhoids.

Consequently it is almost essential to inaugurate a diagnostic routine for all of these cases somewhat as follows: serologic blood test for syphilis; Frei intradermal test for lymphogranuloma venereum; intradermal bacillary antigen tests for chancroid. These skin tests should be read at forty-eight hours and the central papules or area of induration should be 7 mm. in diameter with a halo of erythemata of 14 mm. in diameter for a positive reaction. Smears of ulcers should be studied for Donovan bodies, Ducrey bacilli, fusospirochetes, and other secondary invaders. A biopsy of ulcerated tissue should be sectioned and stained for tubercle bacilli, carcinoma or Donovan bodies.

Therapy. Chemotherapy has been disappointing, as has been the experience in other virus diseases. Anything which increases general resistance is indicated. This should include improved general health by good food, rest and vita-
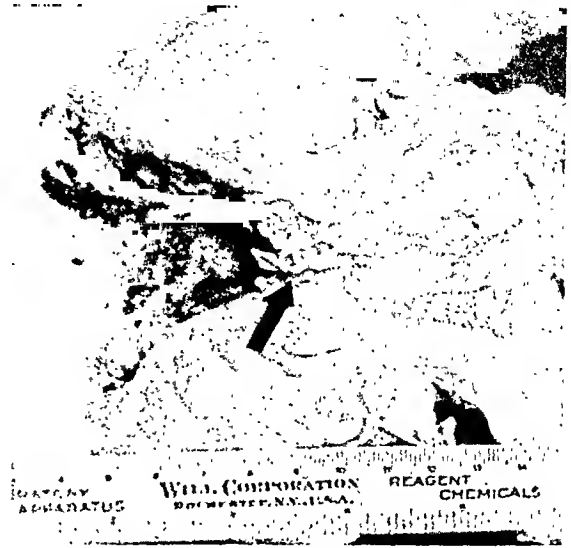
Fig. 3. Lymphogranuloma venereum—rectal syndrome. Arrow points to the stricture of the rectum. This patient developed an epithelioma at the anal margin.

mins, active treatment of complications as syphilis, granuloma inguinale, gonorrhea, chancroid and especially secondary invaders of ulcerations. Active immunity seems to be enhanced in many cases and in some remarkably by repeated Frei intradermal tests or repeated subcutaneous injections of Frei antigen. In one case of rectal stricture in a white female the use of transfusions from the husband who was a Frei positive with a previous history of infection gave marked temporary relief. It may be that passive immunity holds great possibilities.

More recently intravenous injections of small amounts (0.05 to 0.3 c.c.) of Frei antigen have been employed in therapy, but its value over subcutaneous injections has not as yet been evaluated. Excellent results have been obtained with the use of sulfanilamide.* It is of value only in draining buboes, sinus tracts, ulcerations, etc., by its probable action on secondary con-

taminants. Ulcers frequently heal, proctitis and rectal leucorrhea abates and drainage from sinuses ceases. However, it does not

Fig. 4. Lymphogranuloma venereum—genitourinary syndrome. Note the papillary excrescences about the urethral orifice. This patient also has vulvar elephantiasis.

seem to have any definite effect on the secondary lesions per se, such as the rectal stricture, chronic elephantiasis, or growths and papillary excrescenses about the genitalia.

Fluctuant buboes should be aspirated as often as necessary but should not be incised because intractable ulceration may result. Furthermore, the sterilized pus is of value in preparation of Frei antigen. This should be standardized with known antigen. Ulcerations are best treated by cleanliness and elimination of secondary invaders by weak antiseptic and oxidizing solutions. Fusospirochetosis is well managed by a mixture of arsphenamine 4½ per cent in equal parts of glycerine and cod liver oil. This may be applied directly or as a saturated dressing and is more comfortable if

a 1 or 2 per cent solution of a local analgesic is added. As an alternative, a creamy paste of cod liver oil-zinc peroxide mixture may be used. It is less expensive and is quite efficacious.

Rectal strictures are probably best dilated gently once a week. Neglect of this form of therapy on the part of the patient or physician will in the great number of cases ultimately lead to colostomy for relief of an advanced stage of stricture. Since we have inaugurated active treatment of the stricture by repeated dilatation we have not had to perform any colostomies. In the case of elephantiasis and polypoid growths the patient may be greatly benefited by surgical removal of redundant tissue by partial or complete vulvectomy or clitorectomy.

SUMMARY

1. Ninety-six consecutive cases of lymphogranuloma venereum in the female are

analyzed and are found to fall into four overlapping groups, i.e., genital, inguinal, anorectal, urethral syndromes.

lesions per se, such as rectal stricture, elephantiasic vulvae, or papillary excrescences and growths about the genitalia.
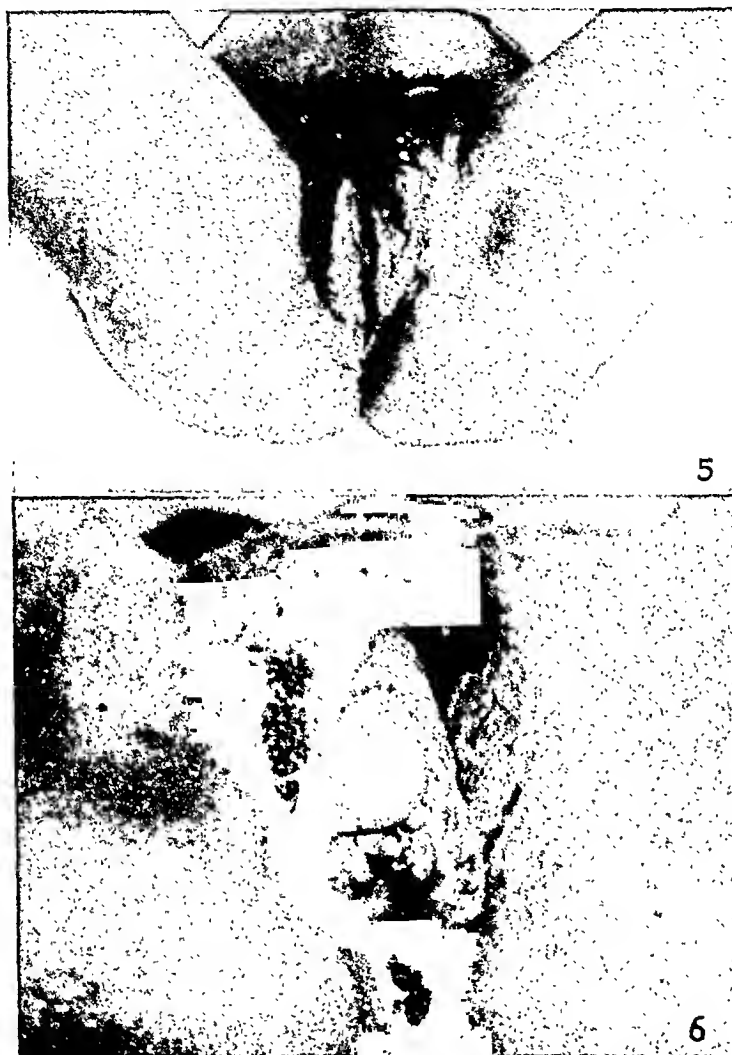
FIG. 5. Lymphogranuloma venereum—inguinal genito-anal syndrome. Note the left inguinal bubo, the multiple draining sinuses and swelling of the left vulva, and the sinus on the inner fold of the left buttocks draining an ischiorectal abscess.

FIG. 6. Lymphogranuloma venereum—genito-anorectal syndrome. Note the elephantiasis of the clitoris and labia, the anal growths. This patient also has a rectal stricture.

2. Various therapeutic measures are recommended. A specific has as yet not been found. Sulfanilamide has proved a valuable adjunct to therapy. It is of value in checking the rectal leucorrhea that is so often attendant upon rectal stricture, as an aid in the healing of ulcerations, and in permitting drainage from ischiorectal abscesses, sinus tracts and draining buboes to cease. However, thus far but little effect has been observed on the secondary

ADDENDUM

Since submission of this paper for publication, we have studied forty-nine new female cases of lymphogranuloma venereum. The distribution of the lesions, the clinical course and symptomatology are much the same as those already described in this analysis. In one patient 5 years of age, bilateral buboes followed attempted rape. Two colored women had

abscesses in the rectovaginal space which were associated with rectal disease. Further observations on sixteen cases treated with

armamentarium. We cannot, however, share the enthusiasm expressed in some recent reports, particularly that of Gjuric

FIG. 7. Lymphogranuloma venereum—genital syndrome. Note the elephantiasis of vulva, clitoris, the pendulous polypoid mass (right lower vulva), and the papillary excrescences.
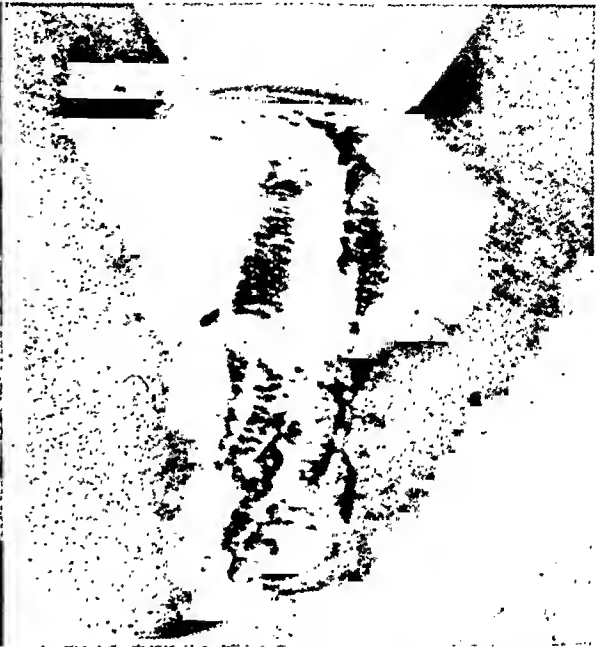
FIG. 8. Lymphogranuloma venereum—genito-anal syndrome. Note the elephantiasis vulvae and the perineal ulceration and growths.

sulfanilamide bear out our earlier findings. It is a valuable adjunct to the therapeutic

(*München. med Wchnschr.*, 85: 335, 1938). We are in agreement with the conservative report of Shaffer and Arnold (*Arch. Dermat. & Syph.*, 87: 7305, 198).

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LEVATOR HERNIA, PERINEAL AND PUDENDAL*

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A HERNIA presenting in the perineum or in the pudendum is a very rare occurrence.

Considerable confusion existed in the classification and nomenclature of hernia at the pelvic outlet until Chase presented his classic paper in 1922. After a review of the literature, cadaver dissections and the successful repair of a pudendal hernia, he concurred in the suggestion of J. A. Blake that the term "levator hernia" is most appropriate, as the primary and essential anatomic feature is a rent in the levator ani muscle.

Anatomic Considerations. A study of the pelvic diaphragm shows that the iliococcygeus portion of the levator does not overlap the central portion (pubococcygeus) laterally, but passes onward to fuse directly with the pubococcygeal and rectococcygeal raphé. This leaves a weak point or space on each side in the pelvic diaphragm, closed only by the pelvic or rectovesical fascia above and separated only by areolar tissue from the ischiorectal fascia below.

Anterior to the broad ligament the levator is fused in a complete layer. This explains why all reported cases with exit at this point were traumatic in origin.

Levator hernia may be divided into the rare congenital or more usual acquired forms, and each group subdivided into the perineal and pudendal types. The latter is again divided into: (a) anterior to broad ligament (direct, subpubic); and (b) combined (indirect anterior) varieties.

A perineal hernia presents in the ischiorectal fossa posterior to the transversus perinei muscle. The boundaries of the internal ring are the board ligament anteriorly, the sacro-uterine ligament and the rectum mesially and an imaginary line between the two sides of this angle. The sac is completely lined with peritoneum. The hernia then perforates the rectovesical fascia and the ischiorectal fascia, descending into the ischiorectal fossa. The sac usually contains bowel, less frequently the tube and ovary.

Pudendal hernia may be anterior to the broad ligament (direct) or combined. The boundaries of the internal ring in the anterior variety are the uterus and the bladder mesially, the round ligament externally, and the transversus perinei muscle and the vagina below. The sac is incomplete, as the bladder, which forms the contents of the sac, has only a partial covering of peritoneum. The point of exit is bounded mesially by the vagina, externally by the ascending ramus of the pubic bone, and posteriorily by the transversus perinei muscle.

After perforating the rectovesical fascia only, the posterior variety may pass downward and forward beneath the broad ligament before perforating the levator. There thus results the combined (indirect anterior) variety, which contains both bowel and bladder.

A pudendal hernia always makes its exit through the suprapubic triangle, protrudes into the posterior part of the labium majus, and vaginal mucosa invests its mesial surface.

The perineal and the combined pudendal are always the "sliding" type of hernia.

Etiology. The anatomic and mechanical factors common to all hernias operate to produce levator hernia. The majority of pudendal hernias, however, have followed

pregnancy and labor, especially the trauma of instrumental delivery.

Diagnosis is made upon the history of a trauma or unusual physical effort, followed by a swelling in the perineum (buttock) or labium majus. The tumefaction may be tympanitic on percussion, imparts an impulse on coughing, is reducible, and its course may be traced by palpation as the hernia is reduced.

Prognosis. A V. Moschcowitz, in an admirable review of the literature (1918) going back to the eighteenth century, found only twenty-eight cases reported as levator hernia, twenty of which were merely clinical observations. In many of these the data were incomplete; four others were operated upon and the remaining four were examined post-mortem. His personal case was a female child of two and one-half years, who had a moderately firm smooth swelling in the right buttock. Incision disclosed the mass to be a subperitoneal lipoma, 6 inches long by 2 inches wide, with a hernia through a hiatus admitting two fingers between the levator ani and the coccygeus muscles. The opening was closed with interrupted sutures of chromicized catgut, reënforced by suturing the lower margin of the mobilized gluteus maximus to the deep pelvic fascia. There was no recurrence ten months later.

Pudendal hernia has usually been considered to be incurable. In the thirteen authentic cases collected by Chase, his own patient was the only one cured by operation (five years). Grattan felt that in the case he reported, the exit corresponded to the cases of pudendal hernia described by Cooper in 1807, and to the cases collected by von Winckel in 1881, which were reviewed by Moschcowitz who listed eleven authentic cases, all in females.

Treatment. Effort should be made to apply the general principles of surgical repair of hernia, namely, high ligation and excision of the sac with closure of the internal ring. Pudendal hernia is a special problem for the gynecologist. Perineal hernia usually presents no insurmountable difficulties of operative technique. If, as generally occurs, intimate adhesions to adjacent structures or to the perineal skin prevent excision of the sac, the internal ring may be closed by suture, with or without circumcising the peritoneum at its margin; or the sac may be obliterated by purse-string sutures of linen, according to the technique of Moschcowitz, as in the following case.

CASE REPORT

Mrs. A., 71 years of age, consulted me in 1935 for abdominal cramps, pelvic pain and frequent bloody dejecta of five months' duration. She was a frail woman, weighing 98 pounds. She was childless and had had an ovariotomy when 36 years old. She suffered from a chronic bronchial cough.

Examination revealed a neoplasm of the rectum 2 inches in length, involving the anterior two-thirds of bowel circumference. The lower margin of the growth was 2 inches above the anal verge. Biopsy showed adenocarcinoma, grade 2.

On December 18, 1935, I established a loop sigmoidostomy under local anesthesia. There was no gross involvement of the liver. Several diverticula containing fecaliths studded each side of the distal half of the long sigmoid, but the mesenteric lymph nodes were not enlarged. The atrophic uterus was in normal position. Three weeks later, under spinal anesthesia, perineal excision of the rectum was performed, during which the cul de sac was opened. After about 4 inches of the sigmoid had been drawn down, the peritoneum was sutured to the sigmoid with interrupted stitches of chromicized catgut. Three months later the perineal wound was completely healed.

Four months after the perineal proctectomy, the patient complained of a bearing down feeling in the pelvis which was relieved when reclining. This became worse, and was accompanied by occasional colicky pain in the lower abdomen.

Examination in July 1936 showed that on straining, a bulging the size of a lemon appeared in the right side of the healed perineal skin. This swelling was soft, tympanitic on percussion, and imparted an impulse on coughing. Its easy reduction was accompanied by a gurgling sound. Palpation indicated that the

internal opening was posterior to the broad ligament and to the right of the pelvic colon.

On August 25, 1936, under spinal anesthesia, the abdomen was entered through a lower left rectus incision. No adhesions were present. With the patient in the Trendelenburg position, it was seen that the true pelvis was occupied by the small intestine, loops of which were prolapsed into but were not adherent to the peritoneal sac at the bottom of the pelvis. The internal opening of the sac, about 1 inch in diameter, was posterior to the broad ligament and just to the right of the pelvic colon. The sac was about 2½ inches in depth and so adherent to the thin perineal skin that it could not be separated. While an assistant held the sac inverted by counter-pressure through the perineum, a purse-string suture of linen was placed just above its apex. Three other similar sutures were then placed at intervals of two-thirds of an inch and when all were tied the sac was completely obliterated. Anterior suspension of the atrophic uterus was effected by two sutures. The abdomen was closed without drainage. Convalescence was smooth. To date (nine months) the patient has had no symptoms referable to the hernia and there are no signs of recurrence.

Of the many cases of perineal excision of the rectum for carcinoma, with permanent colostomy, that I have done, to my knowledge this is the only one to be followed by a perineal hernia. I attribute its occurrence chiefly to the strain of the persistent coughing due to the chronic bronchitis.

SUMMARY

Anatomic studies indicate that a levator hernia descends through a point in the pelvic diaphragm naturally weak or weakened by a trauma.

Levator hernia was rarely congenital; usually it is acquired and is classified as perineal or pudendal.

The boundaries of the internal ring, course and site of external presentation of the two varieties are described.

Cases in the literature are briefly summarized and the writer reports the successful repair of a perineal hernia in a woman, aged 71 years, which followed procteetomy for carcinoma of the rectum.

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THE USE OF PROLONGED ANESTHESIA IN ONE HUNDRED RECTAL CASES

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IN the past, rectal operations under strictly local anesthesia have been rather generally avoided by the average practitioner. Spinal, inhalation and other forms of anesthesia have been preferred and as a result, such operations have not shown a trend towards simplification, as many of us would prefer. The possibility of handling patients suffering from rectal conditions in the office has been almost entirely eliminated, and many simple lesions have been allowed to go on to more serious conditions, chiefly because of the patient's fear of hospitalization.

We can note with relief, therefore, the promised benefits of the newer oil-soluble anesthetics which can be utilized in either office or hospital with great advantage in the average rectal case.

The author has had occasion to use several different compounds for rectal anesthesia, but one in particular, neothesol, has given great satisfaction both from the standpoint of adequate anesthesia and freedom from complications.

Neothesol is composed of two parts of methyl methylene para-aminophenyl-formate and five parts of hydroxbenzo-carbinol in refined almond oil. It contains no phenol and has a benzyl alcohol content of 2 per cent, which is considerably lower than the 10 per cent in most of the oil-soluble preparations. Due to its viscosity, it must be withdrawn from the ampule through a gauge 15 needle, but it can be injected through one of 20 gauge, which is a convenient size and one easily manipulated.

The actual technique of administration is something that cannot be done in any casual manner. Despite its similarity to simple local solutions, there are many important points in which the two classes of solutions differ. One had best begin with a careful anatomic study of the anorectal region because an accurate contact with the nerve fibers is essential. Very little help can be expected from the convenient process of diffusion. As a matter of fact, diffusion would soon nullify the property by which its action is prolonged.

The anatomy of the anal nerves, which is our principal concern, is not so complicated as some of the books would have us believe. The varied terminology was somewhat confusing to the writer, and he found it helpful to dissect several cadavers and actually observe these nerves as they entered the muscles and other structures. A slight amount of variation was noted in some specimens, but it was possible to sum up a conception of these structures in a fairly concise and diagrammatic way.

There are three nerves that are of importance: (1) the coccygeal, (2) the inferior hemorrhoidal, and (3) the sympathetic plexus. The bony anatomic landmarks are easy to find; there are three of them—the right and left ischial tuberosities and the coccyx. If the examiner will place his index finger in the rectum and palpate these landmarks from within, he can estimate with a considerable degree of accuracy the position of the two nerves that supply the skin and sphincter muscles.

The finger will note that the ischial tuberosities are almost directly lateral to the anal ring, and that the coccyx is directly posterior to it, thus forming a right angle. A line dividing this angle in half, or 45 degrees from either bony landmark, will indicate the position of the inferior hemor-

hoidal nerve as it enters the ischiorectal space. The coccygeal nerve, descending from the fourth and fifth sacral, runs, as its name implies, directly from the region of the coccyx to the posterior anal margin. Several fibers of this nerve may exist, some of which are to be found in close proximity to the anococcygeal ligament, while others may be a good inch and a half away from this structure. However, the fibers run parallel to each other and for this reason, can be the more easily visualized. The fibers of the inferior hemorrhoidal nerve enter the outermost border of the sphincters, starting about where the coccygeal nerve leaves off, and progressing onward to the anterior portion of the sphincter muscles and the overlying skin.

The mucosa of the anal canal above the pectinate line receives fibers from the sympathetic group. We are told that these sympathetic nerves are sensitive to traction only, but the act of ligating or clamping in this region will produce ample pain sensation unless the nerves have been well blocked off. The fibers are very fine; they lie in the wall of the gut and completely encircle it in the region of the internal sphincter. Other nerves which give off a few fibers to this area are of no great importance at the moment, and they will be blocked off during the process of caring for the nerves already mentioned, because of their close contiguity.

At any rate, due regard must be had for the vessels that accompany these nerves, because it has always seemed to the author that there must be some practical connection between the spelling of "hemorrhoid" and "hemorrhage." Using a large caliber needle, one must be doubly careful, and yet, when ecchymosis has occurred, as was the author's experience in a few instances following accidental puncture, no harmful results ensued. The anatomy of the muscles in this region and the knowledge of the hemorrhoidal veins, crypts, etc., is so familiar that there is no point in entering into a discussion of that subject at this time. The anatomy described is clearly shown in the accompanying diagrams.

The actual technique of administering this type of anesthetic is as follows:

A point is selected midway between the coccyx and the anal margin, and a wheal is raised in the skin, with novocaine solution. Through this wheal is inserted a 20 gauge needle 2½ inches long, attached to a 10 c.c syringe filled with neothesol. The needle should be inserted to half its depth in order to reach the coccygeal nerves. The solution must be constantly expressed from the syringe, both during insertion and withdrawal, avoiding the filling of any one area with any considerable amount of the liquid. The usual fan-shaped region should be covered, its greatest width extending to slightly more than an inch to either side of the midline, with some of the liquid injected directly into the anococcygeal ligament. The resultant anesthesia will cover the posterior portions of the structures of the anal ring.

The next step is to anesthetize the branches of the inferior hemorrhoidal nerve on both sides. This nerve supplies the lateral and anterior portions of the anal ring. Without fully withdrawing it, the needle is deflected laterally, and infiltration is carried out all along the lateral border of the sphincter muscles, the solution being deposited into the muscle tissue. If one wishes to be bold, the needle may be inserted its full length into the ischiorectal space, directly toward the ischium, thus blocking the nerve itself as it appears from under the gluteus maximus. There is some risk associated with this procedure, however, and it is a maneuver which is not entirely necessary. One can make sure that the sphincters are well infiltrated because their blood supply seems to offer a good defense against injury from the oil. Both the internal and external sphincter muscles receive some of the anesthetic and satisfactory relaxation should be produced immediately if infiltration is accurate.

The subcutaneous tissues, already partially anesthetized by the earlier infiltra-

tion, are now taken care of, still without withdrawing the needle from the original point of puncture. It is important to avoid
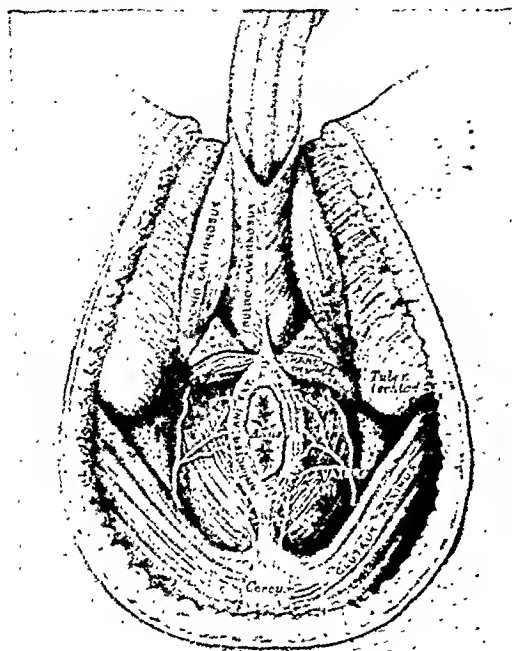
FIG. 1. The coccygeal nerves are seen running from the coccyx to the posterior border of the external sphincter. The inferior hemorrhoidal nerves are seen running from the pudendal nerve to the lateral and anterior borders of the sphincter. The small crosses indicate some of the suggested points of infiltration.

getting the solution too near the superficial layers, not only for the purpose of avoiding sloughing, but also to guard against distortion of the structures to be operated upon. These heavy oil solutions can cause absolute disappearance of an external hemorrhoid by ballooning the tissues in a manner which is far more disconcerting than any ever experienced with novocaine.

Having anesthetized the posterior and lateral areas, the anterior perineum is treated in the same manner, again using the small wheal of novocaine about an inch anterior to the anal ring, through which the larger needle is again introduced. The subcutaneous and muscular structures, which were not reached by the posterior infiltration, are then well anesthetized.

The third group of nerves to be anesthetized is the sympathetics, which descend from above within the wall of the rectum. This is done by deep insertion of the needle, parallel to the axis of the gut and reaching a point where the mucous membrane rolls over the belly of the internal sphincter muscle. Small quantities of neothesol must be deposited throughout the entire circumference of the rectum at this level. This can be easily done from the two points of entry, using the finger inside the rectum as a guide. Only small quantities can be placed at each site of injection since any ballooning of the mucosa is followed thirty minutes later by intense burning. The mucous membrane seems capable of handling the situation without slough, but its distention causes the patient to complain of unbearable stinging which takes a few hours to wear off. The palpating finger can easily recognize the gentle distention of the tissues which is required, and the result is satisfactory anesthesia.

Having encircled the area with the anesthetic and having produced relaxation sufficient to permit of easy dilatation of the ring with two fingers of either hand, one can now proceed to place a few drops of the solution under the lesion itself. This insures a painless approach and permits the operator to draw down, by means of gentle traction, the offending hemorrhoid or polyp, or to spread the tissues widely and permit a full view of the fissure.

The technique described provides complete anesthetization and makes it possible to accomplish an entire hemorrhoidectomy. However, the smaller or more isolated lesions do not require as thorough a procedure, and the anesthetic can be used to desensitize only a particular portion of the circumference of the anus. For an anal operation the sphincters must be well relaxed as otherwise a clear view of the operative field cannot be obtained. If one makes sure of this point, he can use his own judgment as to how much of the superficial area should be anesthetized.

There are a few drawbacks in connection with this compound, and a number of obvious precautions immediately come to

mind. One of these is the necessity of avoiding pooling of the solution in any part of the area involved; necrosis is likely to result from the continued presence of any foreign body in the tissues, and almond oil, with its contained chemicals, is no exception to this rule. Small quantities of it, however, are well tolerated and present no difficulty when caution is observed. Another point which we would all think of at once is the danger of injecting such a heavy substance into the superficial layers of the skin. The resultant distention would be too great to be tolerated, and necrosis or sloughing would follow. Therefore, it is preferable always to use novocaine for the skin wheal. A further contraindication to this method is the presence of acute infection, and one should not consider breaking this rule under any circumstance.

One more difficulty to be faced is the failure of producing proper anesthesia, either at the time of operation or during the postoperative period. This occurred in a small proportion of the earlier cases in this series. We have all experienced some trouble of this type in the use of ordinary local anesthetics, and have many times solved the problem by using larger quantities of the solution. This gross method cannot be resorted to with the oil preparations because sloughing is likely to result, as has already been suggested, from the pooling of too much material in any one area. It is best, then, to rely upon an accurate technique, based on anatomic knowledge of the location of the various groups of nerves concerned.

What results can be expected from the judicious use of these oil-soluble solutions? The writer has reviewed a series of 100 cases, most of which were treated in the office. In this group were included operations upon anal papillae, fissures, fistulae, polypi and hemorrhoids. Among the latter there were fifty-three complete hemorrhoidectomies. Without arranging a lengthy set of statistics, the results can be summarized as follows:

1. The solution is easy to administer.

2. It gives immediate and satisfactory anesthesia, when once the principles of its use are fully understood.
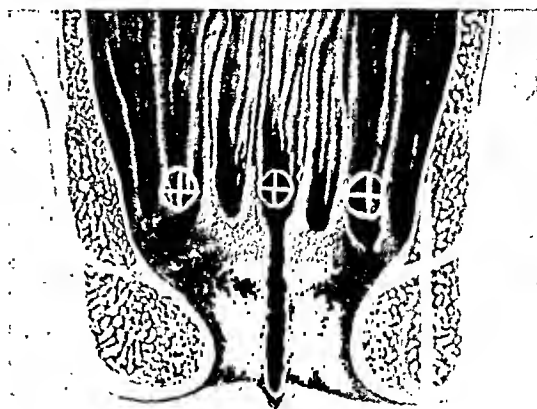
FIG. 2. Cross-section showing infiltration of the mucosa over the belly of the internal sphincter to anesthetize the sympathetic nerves. The lesion shown is that of fissure. The crosses indicate a few of the points of infiltration.

3. Anesthesia does not wear off at the end of an hour, as is the case with the average local solution, but its effects persist and require from one to three weeks to disappear. During this time, the sphincters are partly relaxed, thereby aiding defecation, but in no way causing incontinence.

4. Marked edema of the parts, which was once considered an unavoidable result of hemorrhoidectomy, is now conspicuously absent. The explanation for this undoubtedly lies in the partial relaxation of the muscles previously alluded to.

5. Most helpful of all, the necessity for catheterization has been completely eliminated. In this series in not a single instance was catheterization required.

Three of the patients in this series were physicians and they described accurately the duration of the anesthesia as lasting anywhere from ten to twenty-one days.

In conclusion, it can be said that this method, in experienced hands, is of value as an office or hospital procedure, and possesses the further advantage of requiring only a minimum of attention at home because of the almost complete absence of postoperative pain and edema.

STUDIES ON THE ABSORBABILITY OF CATGUT*

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ONE wonders why, when the majority of modern surgical operations are fairly well standardized, there should be no uniformity of opinion as to the most satisfactory suture material to employ in these procedures.

It is not within the purpose of this paper to submit further proof of the superiority of fine silk over any catgut in the clean surgical wound, but rather to determine what size and kind of catgut most nearly shares the advantageous features of fine silk. When silk is properly used, these advantageous features are: (a) minimum wound reaction in healing; (b) minimum infection in potentially clean wounds; and (c) firm support of the wound throughout its critical healing period. From a workaday standpoint, the meticulous technique demanded in the employment of fine silk discourages its application by those not trained from their first years in surgery to its use. The absorbable suture does get good results with a rougher, more rapid technique; it is unquestionably less tedious and more convenient to use.

Conceding it to be the most popular suture material, there is still great difference of opinion as to what type is most suitable for certain work. For instance, when various surgeons were submitted questions concerning their choice of types of catgut, marked differences of opinion were discovered. To close the peritoneum some used plain o or 1, others chromic oo. For the fascia, the choices ranged as follows: chromic oo, chromic o, chromic 1, plain o, plain 1. For intestinal work the choices were: chromic oo, plain oo, plain ooo. Opinions on absorbability were likewise at variance. One thought that plain catgut is absorbed in from five to ten days; another stated that plain catgut holds two or three days and chromic from ten to twelve days; still another said that plain fails to function after twenty-four hours, and chromic after four to five days; and a fourth: that the safe absorption limit for plain catgut is ten days.

Harvey* has shown that the strength of a clean healing wound (which is dependent upon the orderly proliferation and function of the fibroblasts) follows a curve. For the first four days there is little inherent holding power in the wound, and the suture must provide all the support. From that point on, coincident with the appearance and multiplication of fibroblasts, there is a sharp increase in wound strength up to the eighth or tenth day, when as maximum strength is approached, the curve tends to flatten. By the fourteenth day, the suture is no longer needed for holding purposes. This is as true of the submucosal fibrous supporting layer in the stomach or intestine as it is of the fascia in the abdominal wall.

Briefly, then, the perfect suture will hold adequately for those fourteen days and then disappear, but it must not, during its stay in the tissues, adversely affect the rate of wound healing. Not being certain what size and type of catgut most nearly meets these requirements and finding wide disagreement about it among catgut users, a histologic answer was sought experimentally.

Healthy adult dogs were etherized and subjected to gastroenterostomy under standard surgical conditions. The gastro-

enterostomies and the abdominal wounds were each closed with the suture to be studied and at intervals of twenty-four

ence of gross fragments of catgut, and, incidentally, peritoneal adhesions. Both the gastroenterostomy and the abdominal
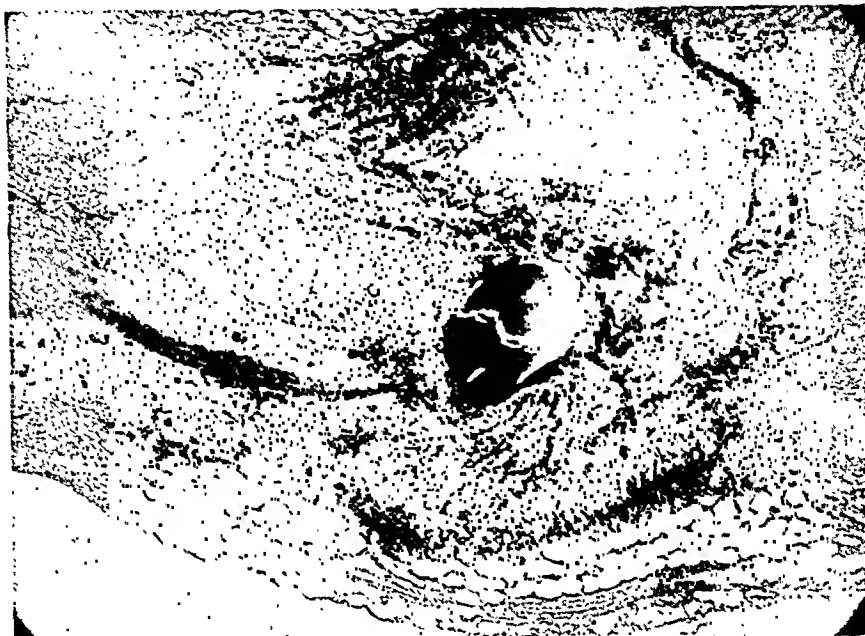
FIG. 1. ooo chromic in abdominal wall at four days. Thirty to fifty cell layers of phagocytes are surrounded by islands of fibroblasts in some parts. Tongues of polymorphonuclears are beginning to invade the catgut.
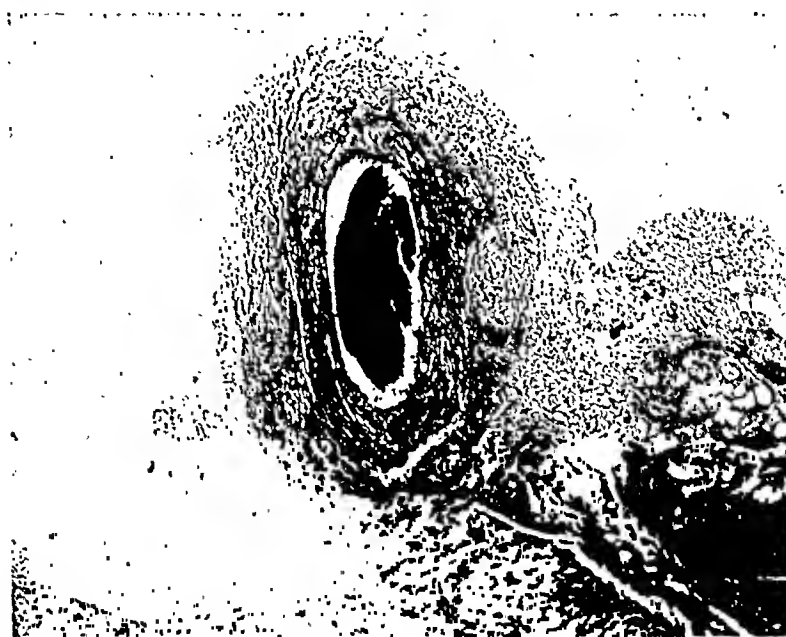
FIG. 2. ooo chronic in abdominal wall at twenty-eight days. Two to five cell layers of phagocytes are surrounded by a wide belt of fibroblasts. The catgut is not more than 30 per cent phagocytized.

hours, four days, one week, two weeks, and four weeks the wounds were examined grossly for the state of healing, persistence of functioning suture (catgut with a demonstrable residue of tensile strength), persist-

wound in each case were examined microscopically after being blocked in celloidin. This permitted microscopic correlation with the gross impression of the state of healing. Special points looked for in the slides were:

(1) amount of exudative reaction or polymorphonuclear infiltration about the catgut (expressed in approximate number of cell

the tissues. Plain and chromic catgut sutures were studied. Size 000 and size 3 were selected to accentuate the results, and size 1* was

Fig. 3. 3 chromic in fascia for twenty-four hours. This shows how quickly begins the splitting of the large catgut, permitting phagocytosis within, as well as from the periphery.

Fig. 4. 3 chromic in a gastroenterostomy for twenty-eight days. A few polymorphonuclear leucocytes are surrounded by a dense cuff of fibroblasts. The catgut has been split six times, and each has undergone phagocytosis until only one-third of the material remains.

layers); (2) the time of appearance and degree of fibroblastic activity (proliferative stage); (3) the degree of phagocytosis of the catgut; and (4) the duration of the catgut in

also used because it is so commonly employed in general surgical procedures.

* There is no standard gauge of catgut sizes respected by all suture manufacturers.

Not only were typical wounds provided by making gastroenterostomies, but an opportunity presented itself then to study

wounds. Bacteriologic studies were not done because it is known that bacteriologic *contamination* always exists in the tissue
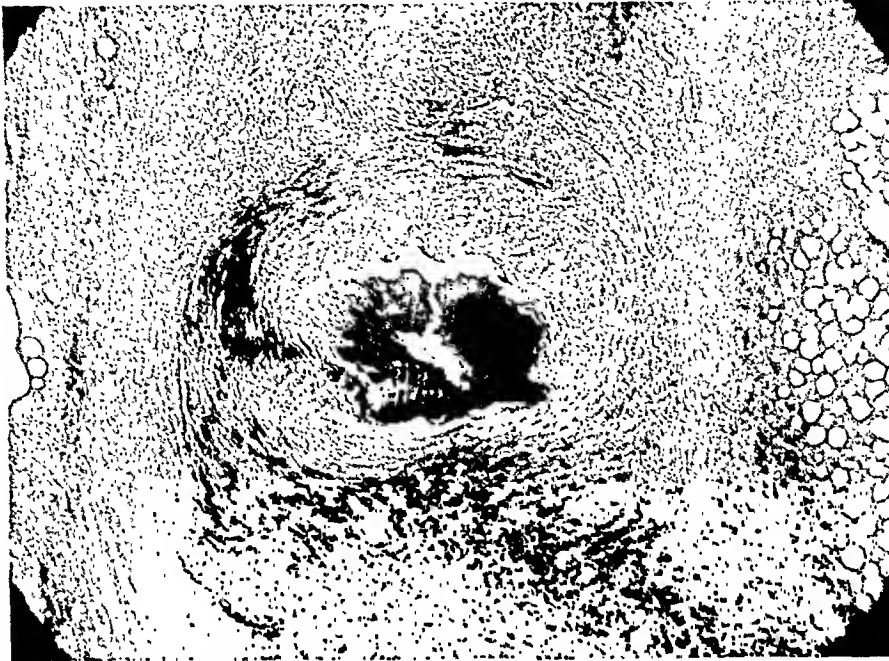
Fig. 5. 1 chromic in fascia for fourteen days. Five to twenty layers of round cells are being surrounded and replaced by an active belt of fibroblasts. The catgut is one-fourth phagocytized.

Fig. 6. ooo plain in abdominal wound for four days. There is a very wide zone of round cell infiltration.

the comparative rates of wound healing in the intestine and in the abdominal wall. None of the dogs to be discussed had grossly infected abdominal wounds, and the absence of peritonitis served as a check on the condition of the gastroenterostomy

from the skin straight on through to the peritoneum regardless of the method of skin "sterilization."

1. Employing *chromic* catgut, studies with the ooo suture showed filmy omental adhesion at twenty-four hours. Grossly, a

beginning self support in the wounds was noted at four days. Fibroblasts had appeared by this time and surrounded a

the end of the twenty-eight-day period, about half of the catgut had disappeared. (Figs. 1 and 2.)
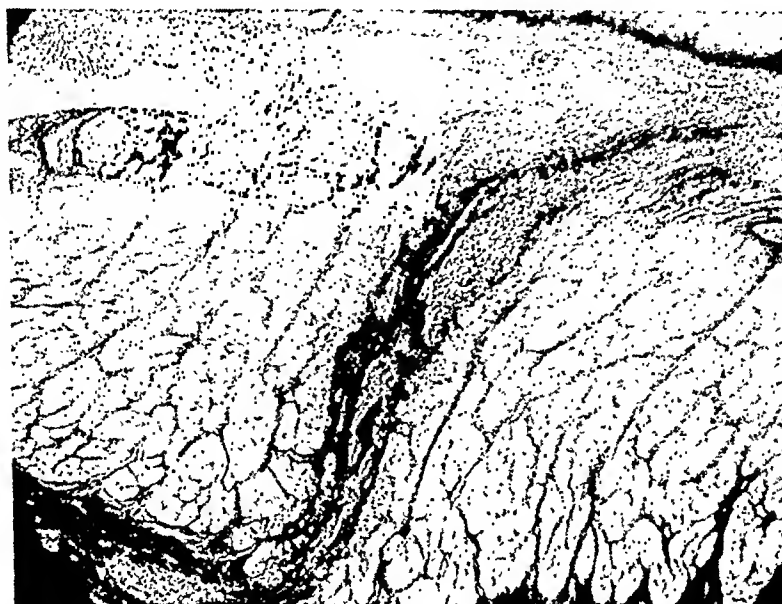
FIG. 7. 000 plain in gastroenterostomy for eight days. Only a few spicules of catgut remain, and these are surrounded by ten to twenty layers of round cells. Fibroblasts have not yet appeared.
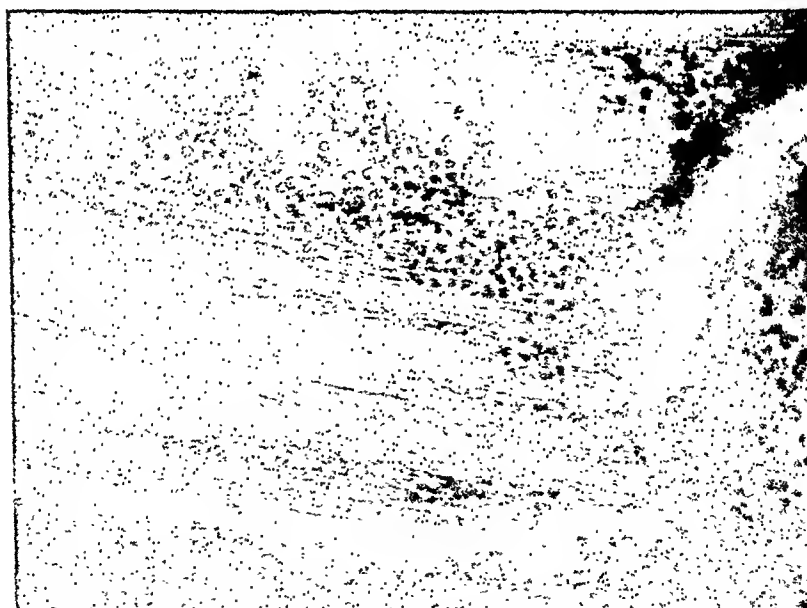
FIG. 8. 3 plain in fascia for eight days (high power). Details of phagocytosis of catgut. Note how it is attacked from within as well as at its periphery.

round cell reaction ten to thirty cells deep from the suture. The catgut demonstrated enough tensile strength to continue functioning for fourteen days in both gastroenterostomies and abdominal wounds. At

2. The size 3 chromic suture was inconstantly associated with adhesions. With it both gastroenterostomy and abdominal wounds healed at about the same rate. At four days, there was no gross healing. Small

green masses of necrotic tissue had col-
lected about the catgut knots. Fibroblasts
appeared by this time to begin surrounding

FIG. 9. 3 plain in gastroenterostomy for fourteen days. There is a zone of
round cell reaction ten to thirty cells deep. Note the fibroblastic activity.
Phagocytosis is about four-fifths completed.
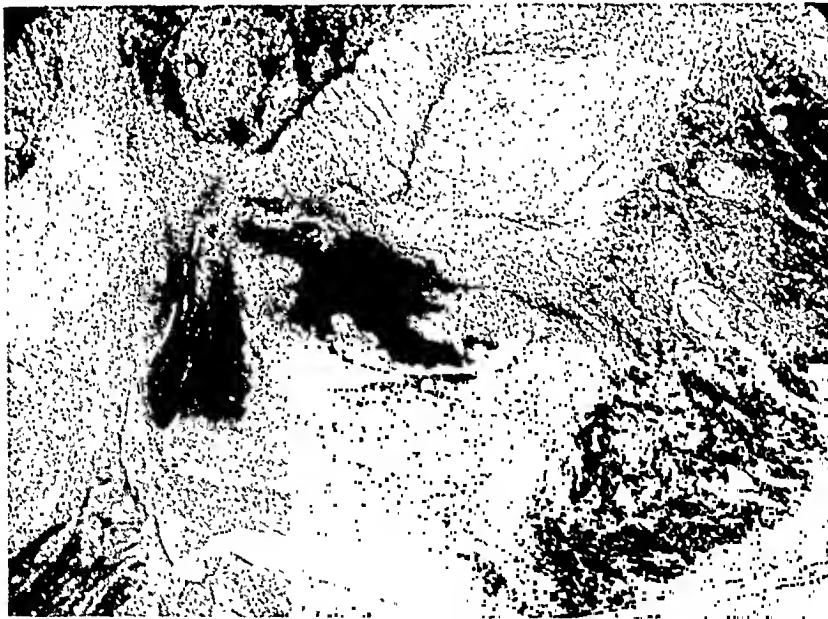
FIG. 10. 1 plain in gastroenterostomy for four days. A polymorphonuclear
reaction fifty to seventy-five cells deep is seen, and phagocytosis is
already well advanced.   There are as yet no fibroblasts.

the five to twenty-five cell layers of poly-
morphonuclears. At eight days, the poorly
healed wounds contained frayed suture,
having little, if any, function. At twenty-
eight days, the catgut was one-half phago-
cytized. (Figs. 3 and 4.)

3. The size 1 chromic suture was associ-
ated with inconstant peritoneal adhesions.
At the four-day period, fibroblasts began to
appear in spots outside of the ten to fifty
layers of infiltrating round cells. The suture
exhibited appreciable tensile strength up to
the fourteenth day, after which swelling
and fraying reduced it to uselessness; su-
ture particles were present at the twenty-

eighth day. Both abdominal wounds and gastroenterostomies healed at about the same rate. (Fig. 5.)

4. Employing *plain* catgut in similar fashion, some interesting contrasts were observed. The size 000 produced prompt, severe, and persistent gross reaction in both kinds of wounds. At four days, the catgut had lost all holding power, and repeated eviscerations occurred then in the experimental animals. By eight days, the last microscopic traces of catgut were fast disappearing and only then did fibroblasts begin to appear. The gastroenterostomies all held, however, through their critical period. (Figs. 6 and 7.)

5. Size 3 plain in wounds caused much reaction. One dog eviscerated in twenty-four hours, but this complicated a wound infection. At four days, there was no gross healing in either type of wound. The suture was weak, swollen, and one-half gone. At this time round cells 200 deep diffused widely into the deeper structures. Fibroblasts appeared by the eighth day, and by the fourteenth day the catgut had disappeared. Healing occurred at parallel rates in both kinds of wounds, and peritoneal adhesions were found in some cases and not in others. (Figs. 8 and 9.)

6. The more commonly used size 1 plain in both types of wounds was not greatly different from the larger catgut, except that grossly there was somewhat less reaction. The suture functioned no longer than four days, and frayed strands persisted for two weeks. From the first, a wide zone of round cells hastened phagocytosis. The fibroblasts appeared after eight days. (Fig. 10.)

There are certain factors which make for inexactitude in such an experiment: the variations in supposedly comparable catgut made by different concerns; the variations in different lengths of the same strand of material;* the inconstancies of local tissue blood supply; and the differences in the tension with which succeeding sutures are tied. Nevertheless, the results are consistent enough to illustrate some useful points.

That any catgut acts as a foreign body in a wound, and detrimentally affects the power of that wound to heal, is a universally recognized fact. Plain catgut is a much more violent irritant, however, than is chromic catgut—and that is not a universally recognized fact. Regardless of the size of the suture employed, plain catgut resulted in slower healing than chromic. At any day examined, the histologic sections showed a wider zone of round cell infiltration around the plain catgut than around the chromic. True, the larger the plain suture the greater the reaction around it; but there was as much infiltration around the smallest plain suture as around the largest chromic.

If the appearance of fibroblasts be considered a criterion for the beginning of healing—the first stage in scar production—then the time of first appearance of fibroblasts might be of significance in learning which catgut is least deleterious to wound repair. Table 1 indicates a relationship between the size and kind of catgut, and the time of first appearance of the fibroblasts.

TABLE 1

Type of Suture	Appearance of Fibroblasts, Days
Chromic	
000	4
1	4
3	4
Plain	
000	8–14
1	8–14
3	8–14

The smallest amount of tissue reaction, the earliest appearance of fibroblasts, the most rapidly healing wounds, occurred when using the 000 chromic suture. The most violent reaction, the most retarded appearance of fibroblasts, the wounds which exhibited edema the longest and

* KRAISSL. Intrinsic factors altering the absorption of catgut. *Surg. Gynec. & Obst.*, 63: 561, 1936. Fractured strands and foreign inclusion bodies are demonstrated in samples of catgut. Kraissl also believes allergy sometimes makes the catgut suture behave unpredictably.

healed the worst, occurred when using the 3 plain catgut.

All agree that chromic sutures exert holding power longer than plain sutures. But how long each holds and to what extent suture size influences the duration of function are matters not so widely agreed upon. Table II lists these sutures in relation to function—that is, the exhibition of demonstrable holding ability of the catgut when the wound was torn down for examination.

TABLE II

	Days
ooo plain	under 4
3 plain	4
1 plain	4
3 chromic	8
1 chromic	14
ooo chromic	14

The eviscerations that repeatedly occurred on the fourth day when using the ooo plain catgut, while making difficult the completion of the series, were expected because that catgut is so tiny and plain catgut is absorbed so fast. But eviscerations were almost frequent at about the fourth day when using size 3 plain. This was more of a surprise—until it was appreciated that the wounds did not start to heal so soon with plain catgut, especially large plain catgut. The 3 plain let go at four days, just as soon as the smaller sizes did.

The table also indicates that the size 3 chromic catgut did not hold up so long as the size ooo chromic. Figure 3, made at the twenty-four-hour period, shows 3 chromic, partly untwisted, permitting phagocytes within the strand almost at once. Figure 4 shows, at twenty-eight days, the fragments of six islands of catgut, which together represent the cross section of what was once one strand. Working with catgut in arti-

ficial media, Kraissl* also came to believe that the large catgut did not necessarily hold longer than the small. Table III, listing the persistence of suture fragments, shows only that, regardless of size, chromic suture becomes a foreign body for more than two weeks after it has ceased to be useful. The small size persisted, presumably because it was thoroughly chromacized, the large by virtue of its excessive mass of chromacized collagen.

TABLE III
PERSISTENCE OF SUTURE FRAGMENTS

		Days	
ooo plain	all	absorbed in	8
1 plain	all	absorbed in	14
3 plain	$\frac{4}{5}$ths	absorbed in	14
ooo chromic	$\frac{1}{2}$	absorbed in	28
1 chromic	$\frac{1}{2}$	absorbed in	28
3 chromic	$\frac{1}{2}$	absorbed in	28

CONCLUSIONS

1. Plain catgut excites a prompt, violent exudative foreign body reaction which delays the appearance of fibroblasts, and so delays wound healing.

2. Large plain catgut is absorbed practically as fast as the smaller sizes, and any size fails to hold throughout the time wound support is needed.

3. Chromic catgut is associated with a retarded and lessened exudative foreign body reaction and with the early appearance of fibroblasts and early healing.

4. Small chromic functions longer than very large chromic catgut.

5. Wound support and healing are most satisfactory when the smallest chromic suture is employed.

* Kraissl. Op. cit. " . . . The table shows that the larger sizes do not necessarily last longer than the smaller sizes. The explanation of this may be that the digestive media penetrated between the ribbons and digests each separately. In chromic gut, the chromacizing may be on the outer layer only, and, when this is penetrated, digestion is rapid, while in the smaller sizes the chromacizing extends through the entire strand."

THE VALUE OF PITRESSIN IN ABDOMINAL SURGERY*

WITH SPECIAL REFERENCE TO DOSAGE AND TECHNIQUE

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IN 1932 a preliminary report on the use of pitressin in abdominal surgery was published. In this report we expressed the feeling that the answer to the paralytic ileus problem lay in prevention rather than in the institution of therapeutic measures once this condition had become clinically evident. To this end, surgical pituitrin and later pitressin were employed, the first injection being given before operation so that the drug might act upon a nondistended intestine and hold it in a state of contraction. Subsequent injections were given at regular intervals in order to maintain this contraction and these were continued through what we termed the "atonic period." We reported 200 cases in which this procedure had been carried out. From 1932 to the present, pitressin has been used routinely on the wards of the First Surgical Division of Bellevue Hospital in 2,500 abdominal cases.

The purpose of the present paper is to reëmphasize the principle of prophylaxis in regard to paralytic ileus, to consider briefly the drug that we have been using, to outline in detail our present technique, to discuss certain side reactions which may be encountered, and finally to render an opinion, based upon a considerable series of cases, as to the value of pitressin in abdominal surgery.

The prophylactic use of pitressin was based upon the supposition that if a condition of hypertonia of the small intestine could be produced before operation and maintained during a sufficient postoperative period, the incidence of paralytic ileus would be materially lessened. This is shown graphically in Figure 1.

The Drug. Pitressin is the pressor and antidiuretic principle of the posterior lobe of the pituitary body. This hormone was first isolated (separated from pitocin, the oxytocic principle of the pituitary gland, and from inert proteins) by Dr. Oliver Kamm and his associates. It is standardized to contain 20 pressor units in each cubic centimeter of aqueous solution.

Technique. Based upon the principle of prophylaxis as stated above, a definite technique is essential if satisfactory results are to be obtained and if certain unfortunate results are to be avoided. During this five-year period we have experimented with dosage of the drug, with varying intervals between injections, and with the mode of administration. We have been particularly interested in the cases in which there have been untoward reactions and have attempted to explain these. Since a definite technique has been adopted, our results have improved and there has been less concern over the question of reactions. The routine use of pitressin is now taught at Bellevue as a part of the nursing course and the student nurses are instructed in detail. The important points are as follows:

1. *Dosage.* To be effective in patients over 12 years of age 1 c.c. (20 units) of pitressin must be used. The manufacturer recommends the 10 unit dosage in adult cases, but we have found this to be ineffectual. During 1935, the standardization of the preparation was altered in such a way that 1 c.c. of pitressin contained 10 pressor units instead of the former 20 units. For a period of months this smaller dosage was used routinely. Our results were far from satisfactory. Pitressin is

now standardized to contain 20 units per c.c. as originally. It is supplied in 1 c.c. ampules containing 20 units, and in ½ c.c.

3. *Mode of Administration.* It is essential that pitressin be given intramuscularly. This not only assures the prompt

FIRST INJECTION
AND OPERATION

A¹ — B¹

A |ııııııı|ıııı|ıııı|ıııı|ıııı|ıııı| B

1   2   3   4   5

C
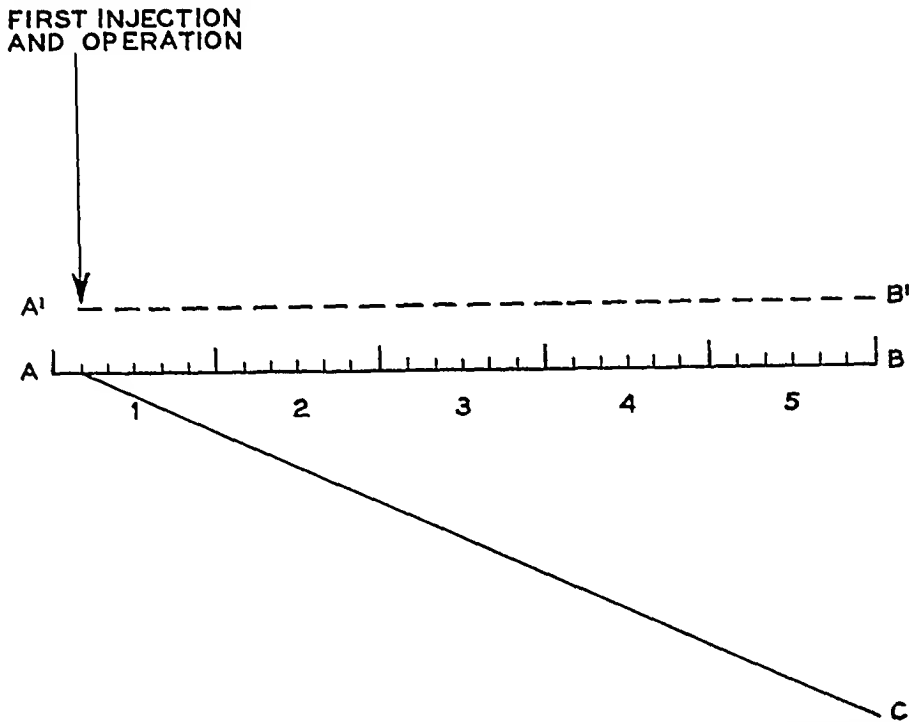
FIG. 1. AB represents normal tone. The figures 1, 2, 3, 4, and 5, represent the days following operation. The solid line AC represents a steady decrease in tone leading to a state of paralytic ileus. The broken line A'B' represents the state of increased tone which we attempt to bring about and to maintain during the first few postoperative days; i.e., during the "atonic period." The small subdivisions represent the periodic administration of the drug.

ampules containing 10 units. To avoid confusion it is at present necessary in ordering the drug to stipulate the number of units desired.

2. *Time and Frequency of Administration.* Where a general or local anesthetic is to be used, the first dose is given as the patient is placed upon the operating table. Where spinal anesthesia is used, the initial dose is given at the end of the operation, as the constricting action of the anesthetic is in force up to that point. Following operation, pitressin is administered every four hours in uncomplicated cases for ten or twelve doses. Where any degree of peritonitis exists, the interval is two hours instead of four. If pneumonia develops, a two-hour schedule is adopted. Ventral hernia cases are also placed on a two-hour schedule, as these are prone to become distended.

action of the drug, but is a means of avoiding accidents. Nurses are trained to administer drugs by the subcutaneous route and their hesitancy in pushing a long needle deeply into the tissues has been one of the difficulties that we have had to overcome. In giving pitressin a 1½ inch needle is used. The left hand is placed in the axilla with the palm toward the arm and the skin over the deltoid drawn taut, compressing the veins in the subcutaneous tissue, thus avoiding an accidental intravenous injection of the drug. The needle is inserted into the posterior half of the muscle far from the cephalic vein. If the skin is under tension and the needle is inserted rapidly, very little discomfort is experienced by the patient.

Action of Pitressin on the Human Intestine. Much of the antipathy toward the

use of pituitary extract in operative cases and particularly in those with any degree of peritonitis is based upon the assumption that this drug produces an extreme degree of peristalsis. It is argued that in the case of diffuse peritonitis hyperperistalsis is not desirable, as infection may be spread from involved to uninvolved portions of the abdominal cavity. Also, experiments carried out with inflated bags placed in various colostomy or ileostomy openings seem to confirm the view that posterior pituitary extract is a violent peristaltic stimulant.

Our clinical observations do not tend to confirm this view. Where pitressin is administered early in the presence of non-distended intestine and continued at regular intervals, there is seldom any evidence of increased peristalsis. Where it is given before operation and the effects in the open abdomen noted, there is a very gradual shrinking of the small intestine, coming on about twenty minutes after the injection. Sometimes this shrinking is uniform, and sometimes it is segmental in type. We have noted nothing in the nature of violent peristalsis. Again, following operation there are seldom signs to point to any violent degree of activity. Gas pains are seldom complained of and the picture has been that of an unusually quiet abdomen. We have used pitressin at regular intervals following obstructive resection and with a few exceptions, the abdomen has remained flat and the patient without the discomfort which one would expect were hyperperistalsis present. We have found pitressin most useful in our cases of diffuse peritonitis where paralytic ileus plays such an important part in the outcome. In these cases we have observed no evidence of hyperperistalsis, and we have been enabled to maintain a relatively non-distended abdomen.

The action of pitressin on distended intestine is quite different. Here it often produces a violent reaction with the expulsion of colonic contents. Clinically, this effect is one of a rapid, sustained contrac-

tion rather than of violent and prolonged peristalsis. In our experience there has been but one instance in which the colon has been emptied on the operating table following the preoperative injection of pitressin. We feel that the results which have been noted experimentally following the insertion of inflated balloons in colostomy and ileostomy openings are analogous to those following the injection of pitressin in the presence of distention, and that these findings do not give a true picture of the action of the drug on non-distended intestine.

Reactions. There are reactions following the use of pitressin. Some of these have only to be understood to be dismissed. In the majority of cases there will be noted a blanching of the skin which has been a cause for unjustifiable worry on more than one occasion. This is a normal pituitary reaction, is the result of constriction of the small vessels in the skin, and is not associated with a fall in blood pressure or a change in pulse. This blanching is to be expected and is of no clinical significance. Some patients will vomit after every injection. This is rarely seen, however, and is unimportant. Abdominal cramps will occasionally follow each injection.

There are two types of real shock produced by the administration of pitressin; the first appears to be anaphylactic in nature, follows every injection of the drug, and is characterized by a fall in blood pressure, pallor, a moist skin, and a thready pulse. This may last for from twenty to thirty minutes. We have seen three instances of this type. The second and more common form of shock may follow the third or fourth injection. There is extreme pallor, a marked fall in blood pressure, and a rapid pulse. These symptoms have not followed preceding doses, and they will not in all probability follow subsequent injections of pitressin. We believe that this type of reaction is the result of accidental and rapid intravenous administration of the drug, and this is the reason for our insistence that pitressin be

given into a taut muscle. There have been ten instances of this type of shock and in each instance the rule as to intramuscular injection had not been observed, the needle having been introduced subcutaneously. None of these patients has died nor are we aware of any report in the literature to the effect that a patient has ever died of pituitary shock.

Treatment consists in the intramuscular administration of adrenalin chloride. We do not believe that reactions are the result of the number of units injected, but are due either to an idiosyncrasy on the part of the patient to pituitary extract or more often to the injection of a full dose of pituitary extract into a small vein in the subcutaneous tissue. We have had reactions following the injection of 10 units, and we have given 40 units without reaction.

Pitressin is not always all-sufficient in the prevention and treatment of distention. We have not hesitated to make use of duodenal suction and of colonic irrigations when necessary. However, the number of irrigations ordered during this five-year period has been far smaller than during the five-year period preceding. This has resulted in the need for less nursing care.

In the bibliography there will be found reference to articles which have appeared during the past ten years. These deal with pitressin rather than with pituitary extracts in general. In a carefully written paper, W. D. Frazier of the Hospital of the University of Pennsylvania and the Harrison Department of Surgical Research has furnished an historical outline of the development of posterior pituitary therapy, a complete bibliography, and has given his opinion as to the value of pitressin in the prevention and relief of adynamic ileus.

CONCLUSIONS

After considerable experience in the routine prophylactic use of pitressin during the past five years, both on the wards and in private practice, we feel that this preparation is a most valuable addition to the equipment of the abdominal surgeon. The fears which have for many years attended the administration of posterior pituitary extract, particularly in cases of diffuse peritonitis, have been shown to be groundless. It has been our experience that in this type of case above all others, pitressin has proved its worth. The drug has been standardized and is surprisingly uniform in its action. However, for the attainment of optimum results and the avoidance of untoward reactions, a definite technique must be adhered to.

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ACUTE AND CHRONIC CICATRIZING ENTERITIS (REGIONAL ILEITIS)

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THE term regional ileitis was first used by Crohn et al.[1] to describe a condition of non-specific inflammatory disease occurring in the distal portion of the ileum. Subsequently, with more widespread recognition of the condition, a variety of names have been given to this process. Erb and Farmer[2] describe their cases under the caption ileocolitis; Meyer and Rosi[3] under the title regional enteritis (non-specific); Galambos and Mittelmann[4] as terminal ileitis; antedating all of them are the old terms, infectious granuloma and sarcoid.

Etiology. Regional ileitis is most frequent in young adults, but it has been reported in patients of various ages. Koster, Kosman and Sheinfeld,[5] in a detailed review, noted its occurrence in each of the first seven decades. Early reports[1] indicated a ratio of two males to one female, but of the seventeen cases reported by Koster et al.,[5] combined with the sixty-two cases in which the sex was mentioned, which they collected from the literature, there were forty-four males and thirty-five females, not a significant difference. Occupation does not appear to be a factor. Crohn, Ginzburg and Oppenheimer[1] noted that members of the Hebrew race appeared to be more susceptible than others, and their observation has been confirmed in subsequent reports. However, Bargen and Dixon[6] failed to note a prevalence of Jews among the numerous cases of regional ileitis observed at the Mayo Clinic.

Although the condition appears to be definitely infectious, various cultural methods, animal inoculations, immunologic procedures and detailed histologic studies have failed to reveal a specific etiologic infectious agent. Felsen's investigations,[7,8,9] indicating that the condition is initiated by acute bacillary dysentery, are an exception to this statement. He obtained positive agglutination titers against organisms of the Eberthella dysenteri group (Sonné-Duval type, especially) in sixty-two consecutive cases of chronic ulcerative colitis, in fourteen cases of chronic distal ileitis, and in two cases of non-specific ileocecal granuloma. Diagnostic bacteriophage reactions and positive fecal cultures for dysentery bacilli were obtained in some of the cases. Control studies of 300 blood sera resulted in 4.6 per cent positive agglutination reactions with E. dysenteri. Acute distal ileitis was observed in fourteen cases of acute bacillary dysentery. Felsen concluded that dysentery in this atypical form at times progressed into a chronic phase and with the aid of secondary non-specific infection resulted in "regional ileitis." In discussing the paper, "A Combined Form of Ileitis and Colitis," presented by Crohn and Rosenak[10] at the 1935 session of the American Medical Association, Felsen stated that "chronic non-specific ulcerative colitis and distal (regional) ileitis, either alone or as associated lesions, and non-specific ileocecal granuloma are all manifestations of bacillary dysentery." Crohn replied that careful

studies of the cases of regional ileitis observed at the Mount Sinai Hospital failed to substantiate this view. The majority of the authors reporting this condition appear to have had similar difficulties in proving a B. dysentery etiology.

Koster et al.,[5] observing a certain similarity of regional ileitis to lymphogranuloma inguinale, applied the Frei test to six of their cases but with uniformly negative results. Mock[11] has reported a number of cases of "infective granuloma" of various levels of the gastrointestinal tract including lesions of the "regional ileitis" type. He attributed the conditions to various non-specific factors, such as appendicitis, foreign bodies, ulcers, extra peritoneal infections, trauma and so forth, and stated that the "condition is directly due to low grade infection causing an impairment of circulation or to an impairment of circulation followed by low grade infection."

Barbour and Stokes[12] suggested that a chronic recurrent intussusception might initiate the process by impairing the circulation and vitality of the gut wall and allowing bacterial invasion from the lumen.

Several authors have submitted statistics indicating that about 50 per cent of these patients previously have had an appendectomy. Obviously, appendectomy in itself would not be an etiologic factor although early symptoms of ileitis are frequently mistaken for appendicitis. Homans and Hass[13] suggest an association between appendicitis and ileitis, stating that in both of their cases there was definite evidence of disease of the appendix. Mixter,[14] among others, expresses himself as opposed to any such relationship.

We must conclude that the exact etiology and pathogenesis of regional ileitis has not been determined; that it appears to be a non-specific inflammatory process initiated perhaps by a variety of factors and aggravated by various constituents, bacterial and otherwise, of the intestinal content.

The *pathology* of regional ileitis is that of a progressive non-specific proliferative inflammatory process.[5,15] In the early phase the involved segment of bowel and its mesentery are edematous and congested. The muscle fibers of the bowel wall are separated by edema, and moderate diffuse leucocytic infiltration is present. Focal hemorrhages occur, particularly near the serosa. There is a hyperplasia of lymphoid tissue in the submucosa and in the adjacent mesenteric nodes. The mucosa along the mesenteric attachment of the gut exhibits longitudinal ulcers. The valvulae conniventes are blunted and indistinct, depending upon the degree of edema.

As the process progresses, the mucosal ulcers extend into the wall and fistulae may form. These often end blindly in the attached mesentery, but, at times, they communicate with another viscus or drain externally. Generalized peritonitis is usually prevented by extensive adhesions. Foci of necrosis with abscess formation are found in the bowel wall and the mesentery. The central part of these foci shows many neutrophiles, endothelial leucocytes and foreign body giant cells, and toward the periphery lymphocytes and plasma cells predominate. Occasionally particles of foreign material, presumably from the lumen of the intestine,[15] are demonstrable. Small foci of inflammation superficially resembling tubercles may be present just beneath the serosa.

Coexistent with the injury and destruction of tissue, there is marked proliferation and repair. Granulation tissue forms at the sites of the ulcers and abscesses, and dense fibrosis of the intestinal wall and adjacent mesentery occurs. Regenerated simple columnar epithelium may cover the ulcerated areas, resulting in a flattened, smooth epithelial surface with no evidence of mucosal folds. In other areas edematous valvulae conniventes form sessile polypi. Eventually, stenosis of the bowel occurs, and the proximal intestine dilates and hypertrophies. Originally, the lesion was believed to include only the terminal ileum, beginning at the ileocecal valve and progressing proximally for 25 to 35 cm. in the ileum.[1] It is now recognized that a non-

specific chronic inflammatory process of this type may involve any part of the intestinal tract.[5, 10, 11, 13, 15, 16, 17]

FIG. 1. Case 1. X-ray taken six hours after oral barium sulfate. Note typical string sign, representing the terminal ileum and dilatation of proximal ileum.

Symptoms. The symptoms of regional ileitis vary with the location of the process in the intestinal tract, its acuteness or chronicity, the duration and extent of the lesion and the presence or absence of complications such as abscesses, fistulae, etc. In the large majority of reported cases the history of the illness is measured by years, ten or more not being unusual. As most commonly the lesion is located in the distal ileum, the majority of symptoms and signs are referred to the right lower quadrant of the abdomen.

Crohn et al.[1] have divided the symptoms into four groups. In Group I the symptoms resemble those of acute appendicitis, with pain and tenderness in the right lower quadrant, fever and vomiting, although the onset is usually somewhat slower than that of typical acute appendicitis. Nevertheless, that many of the early acute cases are mistaken for appendicitis both pre- and postoperatively is attested by the reports

in the literature. The postoperative development of obstructive symptoms or persistence of fistulae finally has indicated the correct diagnosis. It is easy to understand that if an abscess about the cecum is drained, with minimum disturbance of the intestines, detection of the basic process may be missed. Meyer and Rosi[16] reported such an instance in which the persistence of a fistula following drainage of an abscess led to further study. On the other hand, where operation discloses "chronic appendicitis" in a patient who presents symptoms suggesting an acute process, it is difficult to understand how a competent surgeon should miss the real pathology.

Group II includes those cases presenting symptoms of ulcerative enteritis. There is a history of colicky abdominal pain, frequent stools with mucus and sometimes blood. There is also loss of weight and secondary anemia. Repeated stool and proctoscopic studies show nothing definite. Often these patients have a history lasting for years. Galambos and Mittlemann[4] reported a case of this type, the patient having suffered with diarrhea and pain for fifteen years; the persistence of a fistula following appendectomy finally attracted attention to the underlying condition.

Group III comprises those cases with obstructive symptoms which usually occur late in the course of the disease, but in some instances appear suddenly without previous complaints. The symptoms are generally those of an incomplete obstruction of the small intestine. There are cramps, pain, borborygmi, distention and perhaps nausea and vomiting. Often there is a history of recurring attacks of diarrhea.

In Group IV are those cases with fistulae. The fistulae may be of the external type and follow exploration and drainage or they may be of the internal type with a fistulous tract connecting the ileum with the colon or sigmoid. Symptoms occurring in this group of cases vary greatly, but commonly there are diarrhea, loss of weight, anemia and abdominal cramps. There may be intervals of fever during periods of activity.

Individual symptoms occurring in the course of the disease warrant further discussion. Abdominal pain seems to be the

blood is a rare finding. Diarrhea is absent in about one-third of the reported cases.

Nausea and vomiting are relatively in-

FIG. 2. Case 1. Muscularis of terminal ileum. (X62.) Note separation of smooth muscle fibers by edema and diffuse leucocytic infiltration.

FIG. 3. Case 1. Acute ulcer of terminal ileum. (X62.) Observe fibrinopurulent exudate on ulcer base and marked hyperplasia of lymphoid tissue of Peyer's patch.

most outstanding symptom. It is usually of a colicky or cramp-like type and is more commonly located in the lower right quadrant, although it may be diffuse. It may be dull, and it is often relieved by defecation. In the presence of abscesses or fistulae, naturally the pain will be of a different type and location. In some instances, the pain is acute and severe, similar to that seen in appendicitis. Careful review of the reported cases shows a record of pain in nearly every one and the recurring descriptive terms 'colicky' or 'cramp-like' are significant.

Diarrhea is also a common symptom although by no means so constant as pain. Usually there is a history of from four to six soft stools per day. It is uncommon to obtain a history of many movements although Homans and Hass[13] reported the case of a patient who had twenty to thirty stools daily over a period of six years. Occasionally mucus appears in the stools, but

frequent symptoms. However, there is often a history of indigestion and eructation of gas.

Fever is a variable factor. High temperatures are uncommon except in the acute type of case or with the development of complications. A moderate fever of 99 to 102 degrees is present in about 35 per cent of the cases, and periods of fever followed by apyretic intervals are often observed. Loss of weight is commonly noted, varying from a few pounds to 20 or 30. At times, these patients become markedly emaciated and dehydrated. Secondary anemia is an almost constant finding, the degree depending upon the extent and duration of the disease. Leucocytosis is the rule, with a count of about 14,000, although normal leucocyte counts are not infrequent.

The abdominal findings are quite constant. Usually there is moderate distention of the abdomen. Rigidity is absent except in the complicated case. Often there is an

area of tympany due to dilated gut proximal to the lesion. In at least 50 per cent of the reported cases, a mass is

FIG. 4. Case 1. Serosa of terminal ileum. (×140.) Observe extravasated closely packed erythrocytes in subserosal adipose tissue with smaller hemorrhages on serosal surface.

palpable. Usually the mass is located in the lower right quadrant, although it may be in the mid-abdomen. It is tender, rather firm, somewhat irregular in outline and slightly mobile. The size varies from 10 to 40 cm. in length and 5 to 10 cm. in width. In some instances the mass may be palpated through the rectum or vagina. Where partial obstruction exists, peristaltic waves are occasionally visible and audible.

Diagnosis. Roentgenology is of considerable assistance in diagnosing this condition. Crohn and his associates[1] discussed the findings in their original report, and Kantor[18] has described the Roentgen signs in detail. According to him, the oral contrast medium is likely to demonstrate one or more of the following: (1) a filling defect of the ileum (or colon), the size depending upon the extent of the lesion; (2) an area of tapering off immediately proximal to the defect, rather than a sharp change; (3)

dilatation of the gut proximal to the lesion with or without a demonstrable fluid level; (4) the string sign in which a thin linear

FIG. 5. Case 1. Lymph node from iliac mesentery. (×28.) Germinal centers are enlarged and hyperplastic, sinusoids dilated and filled with exudate.

shadow resembling cotton string extends through the obstruction. Barium enema alone is of little value in most cases as it fails to show the lesion.

Regional ileitis is to be differentiated from ulcerative colitis. This can usually be accomplished by proctoscopic examination and a barium enema which will be negative in the former and positive in the latter condition. The history and physical examination, especially of the chest, along with gastrointestinal x-rays will assist in ruling out tuberculous lesions of the intestine. Differentiation from acute appendicitis can usually be made by the clinical findings, although careful examination of the abdomen at operation may be necessary. Great assistance can be obtained from the roentgenologist in ruling out actinomycosis and neoplasms of this region. Finally the condition may be confused with so called "idiopathic spastic enteritis." Usually the symptoms in spastic enteritis are

less marked and are transitory; the roentgenogram is quite different also.

The mortality rate of regional ileitis

Fig. 6. Case 11. Roentgenogram of colon following barium sulfate enema. Observe low position of right half of transverse colon and compare concavity of its inferior margin with diagram of operative findings in Figure 8.

varies with the severity of the process, its duration, magnitude of any operative procedures, etc. Accordingly from the literature one may gather very high as well as low mortality statistics. Binney[17] reviewed twenty-six cases with only one death in the series; Mixter,[14] on the other hand, reported eleven cases with a mortality rate of 36 per cent. A review of a considerably larger number of cases by the present writers discloses a mortality rate of about 12 per cent. It should be noted that recurrences following incomplete eradication of the process are quite frequent.

The *treatment* of regional ileitis depends upon the extent of the disease and the condition of the patient. Meyer and Rosi[16] limited themselves to exploration and appendectomy in three of their eight cases; and careful observation over long periods revealed no further evidence of the disease. These authors suggest that when the edema

is limited to the intestinal wall, infection is localized to this region and probably will resolve spontaneously. If thickening of the

Fig. 7. Case 11. Roentgenogram, six hours after oral barium sulfate. Narrowing of distal 8 cm. of ileum and obliteration of mucosal pattern. Large opaque mass in midline represents dilated proximal ileum.

mesentery and hyperplasia of the neighboring lymph nodes exist, however, this indicates a spread of the infection and makes more radical procedures necessary. Likewise, Probstein and Gruenfeld[19] reported three cases in which the operative procedures consisted of appendectomy with ileostomy; and the ultimate results were satisfactory.

We must be cautious in our appraisal of such conservative treatment, for up to the present, insufficient clinical material is available to warrant final conclusions. We do know that recurrences are moderately frequent even after resection.

If abscesses exist, these must be drained before any further surgery is contemplated. When there is considerable stenosis of gut, resection is indicated if the patient's condition will permit. In some instances, an ileocolostomy seems to afford permanent relief, but usually this procedure is con-

sidered a temporary measure to be followed by resection when the patient's condition is sufficiently good. Meyer and

pain in the right lower quadrant. The pain was steady and accompanied by nausea and vomiting. The patient had noticed a gradually in-
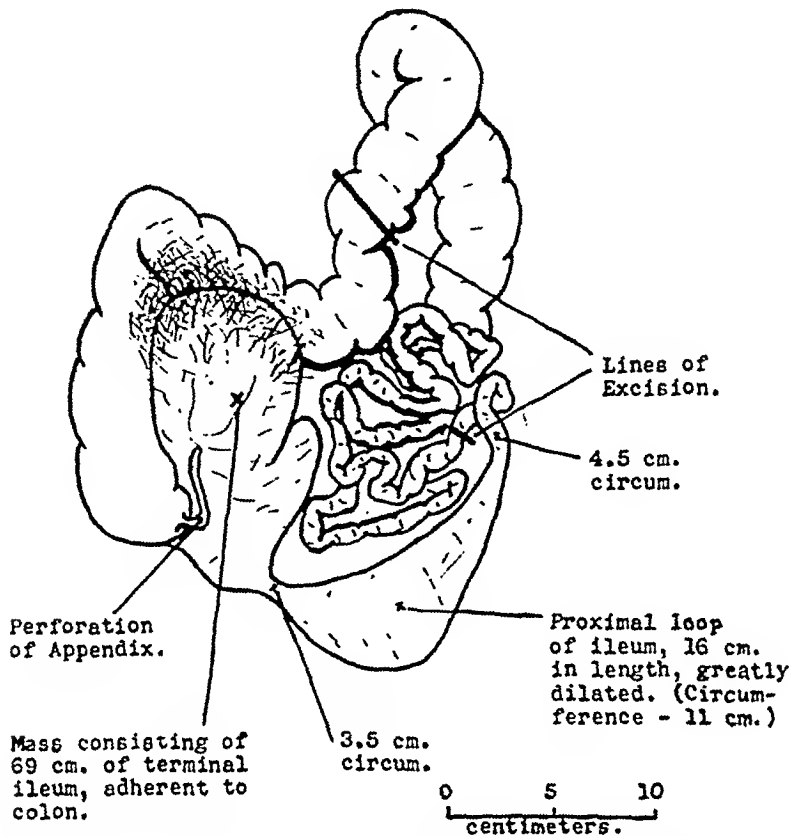
FIG. 8. Case II. Schematic drawing of operative findings. Excised bowel consisted of 98 cm. of ileum attached to 26 cm. of large intestine.

Rosi[16] point out that simple ileocolostomy is followed by recurrence in at least 50 per cent of cases. When resection is done, the line of excision must be well away from diseased tissue, for recurrences are considered to be the result of leaving behind involved areas. Fistulae have to be treated by resection of the tract and excision of the area of the gut involved; perhaps resection may be indicated. Transfusion has found favor as a means of preparing many of these patients for operation.

We present the following two cases to illustrate the clinical and pathologic findings of the acute and chronic phases of regional ileitis.

CASE I.   A young, male Hebrew twenty-two years of age was first admitted to St. Peter's Hospital in December 1935, complaining of

creasing constipation over a period of six months before entrance into the hospital. The family history and past history were negative except for several similar attacks during the past year, always relieved by rest and hot packs. There was no diarrhea nor loss of weight.

The physical examination revealed a rather thin, young male adult apparently in some pain. Heart and lungs were negative. There was definite tenderness over McBurney's point in the right lower quadrant. No masses were palpable, nor was there any marked rigidity. The temperature was 99.2°F., the pulse 88 and respirations 20. Blood count revealed 22,000 leucocytes per c. mm. with 90 per cent polymorphonuclears and 10 per cent lymphocytes. Wassermann examination was negative, as reported later.

The patient was operated upon about four hours after admission, the preoperative diagnosis being acute exacerbation of a chronic

appendicitis. A lower right rectus incision was made and opening of the peritoneal cavity disclosed a small amount of free fluid. The appendix was delivered and found to be slightly swollen and edematous, but not apparently acutely inflamed. Further exploration showed some edema and thickening of the terminal portion of the ileum, which was regarded at the time as no doubt secondary to the appendix. We considered that this would subside following the appendectomy. The patient's convalescence was uneventful, the wound healing by primary union, and he was discharged as cured on the eleventh postoperative day. He was eating well, his bowels were regular, and he complained of no pain. The pathologic report was chronic obliterative and acute appendicitis.

The patient was home for ten days, and during this time he began to complain of vague, transient abdominal pain beginning in the region of the umbilicus and radiating in all directions. The pain was not constant, but was fairly sharp when present. Some belching of gas and constipation were also present. There was no nausea nor vomiting.

He reëntered the hospital, this time on the medical service. The temperature on admission was normal, but varied between 99 and 100 degrees during his stay in the hospital. The pulse varied between 72 and 84. Barium enema revealed a fixation and distortion of the cecum, apparently the result of adhesions from the previous operation. There seemed to be considerable spasm about the cecum. The patient was put on atropine, and this plus rest in bed brought about marked improvement. He was discharged as cured after eight days. The diagnosis was postoperative adhesions and spasm.

However, after about two months at home, he was again admitted to the hospital on March 5, 1936. During the interval he had lost considerable weight and strength. Intermittent pain in the right lower quadrant had recurred in association with nausea and vomiting. For one week before admission he had been unable to retain anything except fluids, and these only in small amounts. Constipation had become more and more severe. Physical examination at this time showed a somewhat emaciated, highly nervous, young male adult. Temperature was 99.2°F., pulse 88 and respirations 20. There were definite tenderness and muscle spasm in the

right lower quadrant, but no masses were palpable. Examination otherwise was negative. The urine was negative; blood sugar was 80 mg. per 100 c.c. of blood; N.P.N. 36.6; urea N. 15.3; chlorides 433; hemoglobin 70 per cent; erythrocytes 4,256,000 per c. mm.; leucocytes 14,000 per c. mm. with 80 per cent neutrophiles and 20 per cent lymphocytes.

Under hot packs and rest in bed the temperature returned to normal, the bowels started moving, and the patient felt considerably better. A gastrointestinal series was done by Dr. I. J. Murnane, roentgenologist, and revealed the typical string sign of terminal ileitis. (Fig. 1.) A diagnosis of this condition was made, and after an attempt to get the patient in as good condition as possible, operation was done.

The terminal 10 to 15 cm. of the ileum and the cecum made up a large mass of acutely inflamed tissue bound closely together with old and fresh adhesions. The mass in some respects resembled a neoplasm. Resection was done and lateral anastomosis performed between the transverse colon and the ileum. The patient's condition was poor and his postoperative course was steadily downhill despite intravenous therapy, etc. Death occurred on the third postoperative day.

Pathologic description of the excised intestine follows:

Grossly, the specimen consisted of a segment of terminal ileum measuring 24 cm., with a portion of the cecum and ascending colon measuring 14 cm. The proximal 7 cm. of the ileum showed a relatively normal mucosa, although the serosal surface over part of this area was congested and granular. From this point to the ileocecal valve, the wall of the ileum became progressively thickened, measuring 1.1 cm. in thickness near the cecum. The most marked thickening was near the mesenteric attachment. The valvulae conniventes became gradually more edematous and blunted toward the ileocecal valve, and were unrecognizable in the terminal 12 cm., where the mucosa showed edematous rounded elevations. An ulcerated groove 1.5 cm. in width extended along the mesenteric attachment of the distal 12 cm. of ileum. Oral to this for 5 cm., there were patches of mucosa at the mesentery with longitudinal acute ulcerations. Small mucosal ulcers were distributed irregularly at points away from the mesenteric attachment. Al-

though the mesentery of the ileum had been cut close to the bowel attachment, a few enlarged hyperplastic lymph nodes could be observed in the remaining indurated, thickened mesentery. The serosal surface showed hemorrhage, while the mucosa of the cecum revealed an irregular ulcer 4 cm. in greatest diameter. The inflammatory process was, however, very much less marked here than in the ileum. The wall of the cecum, which was thinner than that of the terminal ileum, measured 0.6 cm. at its thickest point. Its serosa was congested and roughened by fatty fibrous tags. Several hyperplastic lymph nodes were attached. The appendix was absent.

Microscopic examination of sections through the terminal ileum disclosed edema throughout the wall. (Fig. 2.) In places the mucosa was ulcerated, with the denuded areas showing young granulation tissue containing many thin-walled capillaries and heavily infiltrated with leucocytes, the majority of them neutrophiles. (Fig. 3.) Recent focal hemorrhages were evident beneath the serosa (Fig. 4) and in the submucosa. The wall was diffusely infiltrated with leucocytes, including lymphocytes, plasma cells, neutrophiles, eosinophiles and occasional giant cells. Scattered dense accumulations of neutrophiles were observed in the iliac wall and the mesentery.

The mesentery showed diffuse fibrosis with intermingled areas of fat. Edema, focal hemorrhages and small abscesses were observed, and occasional foreign body giant cells were present in the abscesses. Many of the small arterioles, capillaries, and veins in the serosa and mesentery were acutely inflamed, while the mesenteric lymph nodes were hyperplastic and acutely inflamed. (Fig. 5.)

Sections through the ulcer in the cecum indicated that the base was covered with young vascular granulation tissue heavily infiltrated with leucocytes. The muscle was edematous and infiltrated with moderate numbers of leucocytes. There were collections of lymphocytes beneath the serosa.

The final diagnosis was acute and chronic ulcerative ileitis and typhlitis, with acute hyperplastic lymphadenitis, most prominent in the terminal ileum.

CASE II. A male Hebrew, age 24, entered the Memorial Hospital February 27, 1936 with complaints of diarrhea, loss of weight and weakness, of several years' standing.

According to his parents, his infancy and early childhood had been uneventful; he had grown normally and seemed entirely well. At age 14, he had had an intestinal infection, characterized by diarrhea and loss of weight. From then on, he continued to have similar attacks every two to three weeks, each lasting one to two days. No blood or mucus was noted. At age 14 he weighed 98 pounds, and at 20, 84 pounds. His appetite had always been fairly good. There had been no nausea or vomiting, but of late he had had considerable flatulence. Six weeks previous to admission, the patient suffered with an infectious process followed by jaundice, subsequently proved to be the result of cholelithiasis. At the age of 21, the patient was graduated from an excellent engineering college, but found himself physically unable to follow regular employment.

Examination of the patient upon admission revealed a small, asthenic, pallid male who weighed 75 pounds and was 5 feet 1 inch in height. His skin was slightly yellow, dry and parchment-like due to a minimum of subcutaneous fat. The head was negative except for prominence of the frontal bones which was a family characteristic. The mucous membranes of the mouth were of normal color; there was a hard tumor mass, 2 cm. by 1 cm., located in the center of the hard palate. The teeth exhibited several cavities. The neck was essentially negative. The chest was of the asthenic type with narrow apices and prominent ribs. The heart and lungs appeared normal. The abdomen was soft and flat with a very slight panniculus. The liver dulness was increased to 2 cm. below the costal margin, but its edge was smooth and not tender. The spleen was not enlarged. No free fluid could be demonstrated. In the right lower quadrant of the abdomen, a movable and moderately tender mass about 15 cm. in greatest diameter was visible and palpable, and an unusual, tympanitic area, suggestive of a loop of dilated bowel, was noted to the left of the mass. Rectal examination was negative. The temperature was 98°F., the pulse 80, and the blood pressure 110 systolic and 80 diastolic.

The urine exhibited no abnormalities. Study of the blood revealed the following: erythrocytes 4,040,000 per c.mm.; hemoglobin 14 Gm. (96 per cent Hellige); leucocytes 8,160 per c.mm. with 70 per cent neutrophiles, 25 per cent small lymphocytes, 4 per cent endothelial cells

and 1 per cent eosinophiles; Wassermann reaction negative; non-protein nitrogen 35.5 mg.; creatinine 1.22 mg.; sugar 74.1 mg.; chlorides

genologist, Dr. C. Carter Hamilton, reported a diagnosis of regional ileitis.

On March 2, 1936, under avertin ether anes-

FIG. 9. Case II. Densely scarred muscularis of terminal ileum. (×62.) Note dense snarl of collagen fibers, moderately infiltrated with leucocytes, replacing smooth muscle layer.

FIG. 10. Case II. Muscularis of terminal ileum. (×140.) Granulation tissue densely infiltrated with plasma cells, lymphocytes, neutrophiles, eosinophiles and occasional foreign body giant cells. A few fragmented smooth muscle bundles remain.

472 mg.; calcium 11.3 mg.; cholesterol 104 mg.; icteric index 21.6. Agglutination tests for B. typhosus, paratyphosus A, paratyphosus B and B. abortus were negative. Examination of stools failed to reveal ova or parasites and stool cultures yielded no significant organisms.

Radiographs of the gall-bladder revealed poor concentration of the dye and showed many shadows resembling calculi. Barium enema filled the large bowel completely. The right half of the transverse colon was low and its inferior margin presented a concavity suggesting pressure from an extrinsic mass. There was some smoothing out of the descending colon and sigmoid. (Fig. 6.) Barium meal showed the esophagus and stomach to be normal. At six hours, the stomach was empty and the head of the column was at the cecum. There was a definite narrowing of the distal 8 cm. of the ileum with obliteration of the normal mucosal pattern. The lumen of this portion of the ileum measured 5 mm. in diameter. Proximal to this was a large dense shadow apparently due to dilated loops of ileum. (Fig. 7.) The roent-

thesia, the abdomen was opened through a 5 inch right paramedian incision. No increase of free fluid was noted. Occupying the lower right portion of the abdomen was a conglomerate mass of intestine adherent to the posterior peritoneum and to the greater omentum. After the latter was dissected off, the details became evident. In places the mass was hard and nodular. It was almost impossible to differentiate afferent and efferent loops, but included in the mass were a segment of distal ileum, the cecum, the ascending colon and part of the transverse colon. There were many palpable glands in the mesentery. The ileum proximal to the mass was dilated. (Fig. 8.) A resection of the distal 100 cm. of the ileum with the cecum, ascending colon and proximal half of the transverse colon was then done. An end to end anastomosis was established and tube enterostomy made above the site of union. The tube was brought out through a stab wound of the right loin and the abdominal wall was closed in layers without drainage. At the con-

clusion of operation, the patient was given 500 c.c. of citrated blood. This was followed by continuous intravenous administration of 5 per

the hospital, the patient continued to gain in weight and strength and in two months resumed employment.
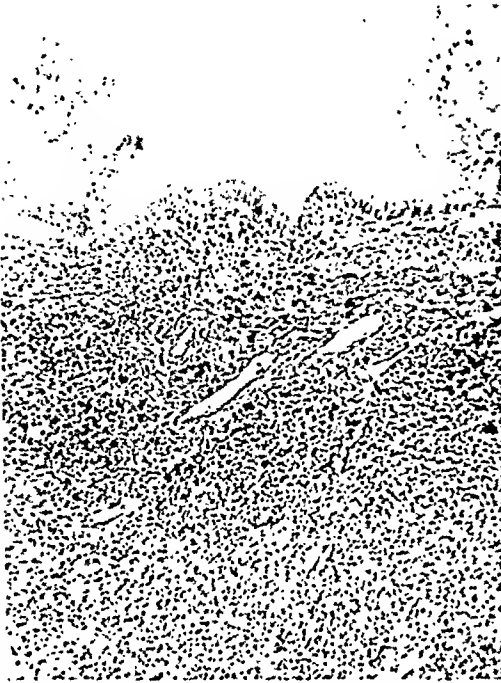
FIG. 11. Case 11. Lining of terminal ileum. (×140.) Normal mucosa and submucosa are absent. Regenerated simple columnar epithelium covers chronic granulation tissue.

FIG. 12. Case 11. Focus of necrosis in iliac mesentery. (×62.) Central necrosis with numerous foreign body giant cells, endothelial leucocytes, lymphocytes and plasma cells. Outer zone of fibrosis. Resemblance to tubercle formation is slight.

cent glucose in normal saline at the rate of 3,000 c.c. in twenty-four hours.

The postoperative course was not remarkable. Two days after operation, the enterostomy tube commenced to drain and auscultation revealed feeble peristaltic sounds. The abdomen was soft. The temperature went to 101°F. and the pulse to 110. Early on the morning of the third postoperative day, the patient had a spontaneous bowel movement. He was then allowed water by mouth in small amounts. On the fourth postoperative day, the abdomen was flat and the patient had two more spontaneous liquid stools. On the seventh day the enterostomy tube came out. Two days later the sutures were removed and the wound healed by primary intention. On the eleventh postoperative day the patient was allowed to sit out of bed. His diet had been gradually increased and he was ravenously hungry. Nineteen days after operation the patient was discharged from the hospital. At that time, he was having eight to ten bowel movements per day, most of which were partly formed. Following discharge from

One year after operation, the patient appeared greatly improved. He reported that he was eating well, had had no indigestion nor pain, but did have four to six formed stools in twenty-four hours; his weight was 110 pounds.

The specimen removed consisted of the terminal 98 cm. of the ileum attached to 26 cm. of large bowel, including cecum, ascending colon, and part of the transverse colon. Approximately 70 cm. of the terminal ileum was bound together as a mass of adherent loops. Over the lower anterior surface of this mass, an appendix 9 cm. long was densely adherent. Fibrous adhesions also were present between the coils of ileum and the transverse and ascending colon and the cecum. The appendix was sharply kinked 1 cm. from its base. The opening of the appendix revealed a mucosal polyp covering a perforation which extended completely through the appendix into the adjacent indurated mass of mesentery and coils of ileum. After freeing the ileum from adhesions and extending it at full length, it was found that

the tip of the appendix was adherent to a point on the ileum 57 cm. from the cecum.

For a distance of 17 cm. from the ileocecal valve, the mucosa of the ileum was smooth, pale and granular, with complete obliteration of valvulae conniventes. The lumen of this portion was greatly narrowed, the bowel circumference being 3.5 cm. The wall was moderately thickened at the mesenteric attachment, measuring 0.7 cm., but only slightly thickened over other parts of the circumference. Proximal to this for 23 cm., the mucosal folds were visible, but were blunted and edematous. The bowel at this point measured 0.4 cm. in thickness and 4.5 cm. in circumference. An ulcerated gutter extended along the mesenteric attachment of this portion. Proximal to this for 29 cm. the wall was markedly indurated, measuring 1.1 cm. in thickness, with the circumference about the same. The mucosal plicae were obliterated and the lining showed a coarsely granular, dull white surface. At the proximal limit of this segment, the lumen became markedly constricted, and in this region there were two perforations which could be probed into the thickened mesentery. Proximal to this, there was a loop of ileum 16 cm. in length and greatly dilated, the circumference being 11.0 cm. The wall of this portion was densely scarred and measured 0.7 cm. in thickness. The mucosa was coarsely granular and showed no valvulae. Proximal to this for 11 cm., the ileum was constricted to a circumference of 4.5 cm. and the wall thickened to 1 cm. A gutter-like ulcer was present along the mesenteric attachment and irregular ulcers were scattered over the rest of the mucosa, but the mucosal folds remained indistinctly visible. The proximal 2 cm. of the specimen showed relatively normal ileum.

The attached mesentery was greatly hypertrophied and scarred; it was 2 cm. in thickness, and contained enlarged, hyperplastic lymph nodes. Scattered small abscesses filled with yellow purulent material were present in the dense fibrous tissue.

The mucosa of the appendix, except in the neighborhood of the perforation, appeared relatively normal, as did also that of the cecum and colon. The muscularis was not remarkable. The serosa of the large bowel was roughened by fatty fibrous tags.

Of the several sections of the ileum studied, some showed the muscle obscured by dense scar tissue (Fig. 9) and the mucosa almost completely absent. In its place was a layer of granulation tissue densely infiltrated with plasma cells, lymphocytes, neutrophiles and eosinophiles, with scattered foreign body giant cells present in places. Such granulation tissue extended deeply into the bowel wall at various points. (Fig. 10.) Occasionally, it was covered by a layer of regenerated simple columnar epithelium. (Fig. 11.) Other sections showed less of the muscle coat replaced by fibrosis and more intact mucosa.

The serosa and mesentery were densely scarred and hyperplastic, chronically inflamed lymph nodes were observed. Some sections revealed small foci of necrosis surrounded by dense lymphocytic and plasma cell infiltration with an outer zone of dense fibrosis. In the central part, endothelial cells and numerous foreign body giant cells were present. (Fig. 12.) The resemblance to tubercle formation was very superficial.

The appendix was not sectioned at the site of the perforation, but sections near this area showed intact mucosa with moderate scarring and leucocytic infiltration of the wall. The serosa was covered by fibrous tags.

The colon appeared relatively normal in the sections studied. The serosal surface was covered by congested, fatty, fibrous tags infiltrated with lymphocytes and plasma cells plus a few neutrophiles.

Cultures and smears made by the surgeon, and cultures, smears and animal inoculations of macerated tissue selected by the pathologist from ileum, lymph nodes and mesentery, revealed no significant organisms.

The pathologic diagnosis made was: chronic stenosing ulcerative terminal ileitis; perforations of appendix and ileum with fistulous tracts into iliac mesentery; chronic localized peritonitis; chronic hyperplastic lymphadenitis.

Two years after the primary operation, this patient was readmitted to hospital with an incomplete intestinal obstruction; there was some vomiting, moderate abdominal distention, but not complete obstipation. He was treated by continuous duodenal drainage, hot packs and intravenous fluids, but did not improve. Three days later, under spinal anesthesia, a jejunostomy was done but no attempt at exploration of the abdomen was made. This procedure afforded but temporary relief and the patient expired forty-eight hours after the jejunostomy.

At post-mortem, the peritoneal cavity contained about 200 c.c. of thin, cloudy reddish-

brown fluid which had penetrated to all portions of the sac. The serous surfaces of the bowel and the parietal peritoneum were dull

The large bowel, 74 cm. long, had a circumference of 4.5 cm. Its mucosa showed no ulcerations, but at the site of anastomosis of

FIG. 13. Case 11. Portion of intestinal tract removed at post-mortem. The longer segment is small intestine and the short one is colon. Note the comparative size of ileum and colon, the ulcers of the mucosa of the ileum and probe passed through stenosed site of anastomosis.

and covered with a thin layer of fibrin. The distal portion of the terminal ileum was adherent to the right anterior aspect of the pelvic brim by fibrinous adhesions. Very slight traction on the bowel caused lacerations in the bowel wall at the sites of several large ulcers. The bases of the ulcers remained attached to the parietal peritoneum and a large amount of thin, dark brown intestinal fluid ran out through the perforation.

The combined length of the large and small bowel was 200 cm. The small intestine, 125 cm., was markedly dilated and filled with a thin, dark brown intestinal fluid. Its serosa had a bluish color. The upper third was 9 cm. in circumference, the middle third 10 cm., and the lower third 12 cm., while the bowel was 0.3 to 0.4 cm. thick. The distal third had many large ulcers varying in size from 0.3 to 3 cm. in diameter and tending to have their long axes perpendicular to the long axis of the bowel. The edges of the ulcers were clean and free of tubercles. The ulcers were so numerous that they covered about 30 per cent of the mucous surface in the lower third of the small intestine. The mesentery was slightly thickened and edematous and contained a few enlarged lymph nodes.

the ileum and colon there was a stenotic region 1 cm. wide with an internal diameter of 0.4 cm. (Fig. 12.)

The other abdominal viscera were not remarkable.

Microscopically, the mucosa of the ileum showed many ulcers which in some places extended down to the muscle layer, and even the remaining mucosa was edematous and infiltrated with polymorphonuclears and some monocytic cells in places, especially beneath the ulcers. The ganglion cells of the mesenteric plexus were granular and swollen. Many large collections of large and small monocytic cells were present between circular and longitudinal muscle layers. The serosa was thickened, edematous, infiltrated in some places with many polymorphonuclears and monocytic cells and was covered by a thin layer of fibrin.

Final diagnoses were: acute and chronic ulcerating enteritis; sero-fibrinous peritonitis; ileocolostomy (old) with stenosis at site of union; intestinal obstruction.

DISCUSSION

Clinically, these two cases agree in almost every respect with the disease entity, regional ileitis, as described by

Crohn and associates.[1] Case I ran a more acute course than most of those described, and Case II a much more chronic course, but wide variations in this respect are mentioned. Case II indicates the tendency to recurrence months after an apparently complete excision of the diseased intestine.

The pathology of these cases varied in certain definite ways from that first described by Crohn. Case I revealed typical involvement of the ileum and mesentery, but an acute ulcer of the cecum was present. The appendix in this case was probably "free from guilt" but its lumen was partially obliterated by fibrosis. The acute changes observed were peri-appendicitis, apparently secondary to the ileitis. Case II exhibited typical chronic ulcerating cicatrizing ileitis, or the "stenotic phase of regional ileitis," but the process irregularly involved the terminal 96 cm. of the ileum and an old perforation in the appendix might logically explain the entire pathogenesis.

Demonstration of a specific etiology for either of these cases was impossible. We believe they are further proof in support of the statement of Homans and Hass[13] who, after carefully studying two cases of this group, concluded: "We agree that a terminal ileitis presents a rather characteristic clinical picture, but acceptance of the local lesion as a pathologic entity is certainly premature, since criteria are lacking by which one can segregate this granulomatous process from similar lesions occurring elsewhere in the intestinal tract."

CONCLUSIONS

1. We believe regional ileitis to be a definite clinical but not a definite pathologic entity.

2. The terminal ileum, cecum and other parts of the small or large intestine may be involved in the process.

3. Diagnosis rests on the history, finding of a mass in the right lower quadrant, plus the typical string sign shown by x-ray.

4. Complete gastrointestinal series should be done in any suspected case, as the lesion does not always show up with a simple barium enema.

5. Treatment depends on the findings in each individual case and varies according to the acuteness or chronicity of the process. Resection eventually may be necessary in order to bring about a complete cure, but in the acute cases it is sometimes better to do a preliminary ileostomy, colostomy or anastomosis, with resection at a later date.

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INFILTRATIVE ANESTHESIA IN SURGERY OF THE GALL-BLADDER

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LOCAL infiltrative anesthesia has a definite place in abdominal surgery, particularly in cases where other types of anesthesia increase an already grave risk. It should not be used to the exclusion of general anesthetics, but if employed in judiciously selected cases, it will materially reduce the hazard of operation. It may be the method of choice in certain types of cardiac decompensation, in acute respiratory and some chronic respiratory disorders, in oral or pharyngeal infections and in some cases of chronic nephritis and hypertension. It should be used in the presence of a marked or dangerous degree of disturbance of acid-base equilibrium where time does not permit delay to correct the condition.

Not all patients are favorable subjects for the use of this method. The usual contraindications for its use are nervousness and fear on the part of the patient and lack of familiarity with technical procedure on the part of the surgeon. Ordinary apprehension is not of especial importance as some of the most coöperative patients are those who look forward to the procedure with considerable dread.

A consideration sometimes overlooked is the increased time required to complete the operation. This necessitates speed in operating sufficient to permit the work to be finished within the duration of anesthesia, which is ordinarily from forty-five to sixty minutes. Repeated use of the method leads to increased speed and proficiency so that reinforcement of the original infiltration is rarely required.

It must be impressed on the patient that local anesthesia differs from general anesthesia only in the consciousness of the patient and that no pain or suffering is to occur. If such a status cannot be maintained the method is of no value to patient or surgeon and should be modified or abandoned in any given case. The patient must also understand that pain is not to be confused with sensations of pressure, as the anesthetic will block all pain. The patient may, however, be conscious of tactile sensations when incisions are made or pressure is applied. It is extremely difficult to prevent discomfort when traction is applied to the attachment of any viscus and when such traction is unavoidable the underlying nerve supply must be thoroughly anesthetized.

The commonest causes of failure to obtain satisfactory painless relaxation are the indiscrete use of retractors, traction on visceral organs, pressure on the thorax or abdomen by the forearms of surgeon or assistant and failure to allow sufficient time after infiltration before beginning the operation. Essential to success are a sharp knife and sharp dissection of tissues rather than separation of layers by blunt or gauze dissection.

The nerve supply to the abdominal wall in the area from the costal edge to the level of the umbilicus arises from the seventh to tenth dorsal nerves. These nerves run obliquely to the long axis of the abdomen downward and inward from the level of the costal arch in a line roughly a continuation of the ribs. With their primary anterior and posterior divisions and cutaneous branches they constitute for practical purposes three separate sets of nerves to the abdominal wall: (1) sensory nerves to the skin; (2) motor and sensory nerves to the abdominal muscles; and (3) sensory nerves to the parietal peritoneum. The main trunks are quite uniformly parallel and equally spaced

in the upper abdomen, but because of the large amount of terminal overlapping on the same and opposite sides the use of

morphine ⅙ gr. The use of such premedication assures a restful night and a tranquil state of mind at the time of opera-
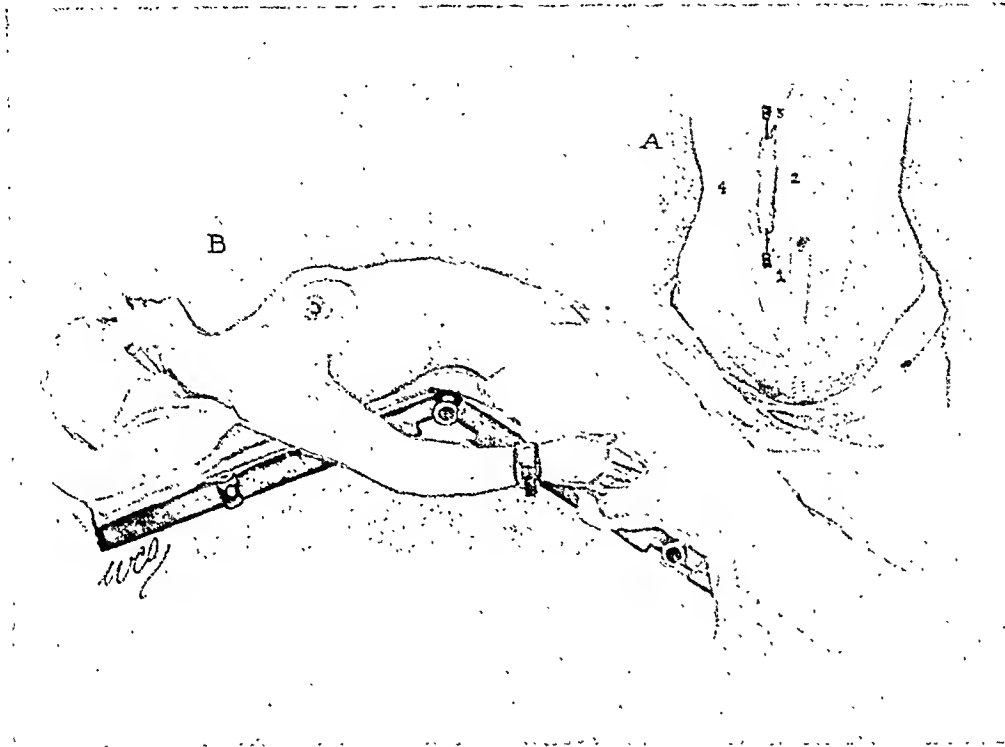
Fig. 1. a, superficial infiltration along the line of incision. Numbers 1, 2, 3, 4 mark outlines of area of infiltrative block. b, position of patient to obtain postural rotation of liver and gall-bladder. Note: The position of the right arm is obviously incorrect and is so drawn to permit a view of the dorsal elevation of the body.

purely conductive nerve blocking is not practicable and the local infiltrative block must be employed. So great is this overlapping of sensory fields that a single spinal root may be severed and hardly a trace of skin anesthesia result.

The nerve supply to the visceral area involved in cholecystectomy arises mainly from the eighth and ninth dorsal nerve roots, the nerves passing to their destination through the rami communicantes and the splanchnic and celiac sympathetic plexuses of the abdomen.

Premedication consists of the administration of 1½ gr. of pentobarbital sodium by mouth at 9 p.m. on the night before operation. A similar dose is given two hours before operation and is repeated one hour before operation, at which latter time ¼ gr. of morphine is given hypodermically. In women or in men of small stature the dose of pentobarbital sodium is 1 gr. and of

tion and has the added merit of counteracting any toxic effect of novocaine. The combined use of barbiturates and large doses of epinephrine may precipitate untoward complications as may also the combined use of large doses of barbiturates and morphine, but no ill effects have been noted in the dosage suggested.

In the recumbent position the gallbladder lies largely hidden by the parietal surface of the liver at the level of the ninth costal cartilage in the plane of the lateral margin of the right rectus muscle. Despite the numerous attachments of the liver by large vessels, ligaments and peritoneal folds a surprising degree of mobility can be attained by postural or traction rotation when the fixative action of the anterior abdominal wall is removed. Since traction is likely to produce pain and nausea, the method of postural adjustment is best employed.

In the position illustrated (Fig. 1), a 15 degree reverse Trendelenburg position with dorsal elevation, the liver slides

syringe to which is attached a small gauge rubber tubing 12 inches in length. At the distal end of the tubing is an angulated

FIG. 2. Infiltration at attachment of gall-bladder to liver.

against the diaphragm into a position of posterior rotation, elevating the anterior edge and exposing the entire length of the gall bladder without the use of traction. If the patient is placed in this position before being draped, rotation will usually be completed when the abdomen is opened and the gall-bladder will lie fully exposed immediately beneath the peritoneum. Occasionally it will be found necessary gently to assist rotation with the hand, but, once rotation is established, no instrumental retraction need be used to hold the liver in position.

A ½ per cent solution of novocaine is used for all infiltration. Five drops of epinephrine solution 1:1000 is added to the first ounce only and this is used to infiltrate the line of incision. The injection apparatus has been reduced to the utmost simplicity and consists of a 5 c.c. luer syringe with a small gauge angulated needle and a 100 c.c.

adapter which will receive a Luer needle 3 inches long. Angulation of the adapter greatly facilitates injection along planes parallel to the skin surface. The needle is directed by the surgeon and the syringe is handled by an assistant who maintains continuous pressure on the plunger.

A high right rectus incision of 4 or 5 inches will furnish adequate room for exposure without need of heavy traction and without the disconcerting expulsion of loops of intestine through the wound.

With the small syringe an intradermal wheal is raised at a point 1 inch below the lower end of the proposed incision. (Fig. 1A.) Changing immediately to the large syringe, the surgeon introduces the long needle through the same wheal and advances it subcutaneously along the entire line of incision and upward to the costal edge. With the needle vertical, the tip is plunged through the anterior sheath of the

rectus and the solution is injected sub-fascially along the same line. The level of subfascial injection is easily determined

from failure thoroughly to flood the lateral costal angle. Distortion of structures may be avoided by dispersing the injected fluid

Common duct.
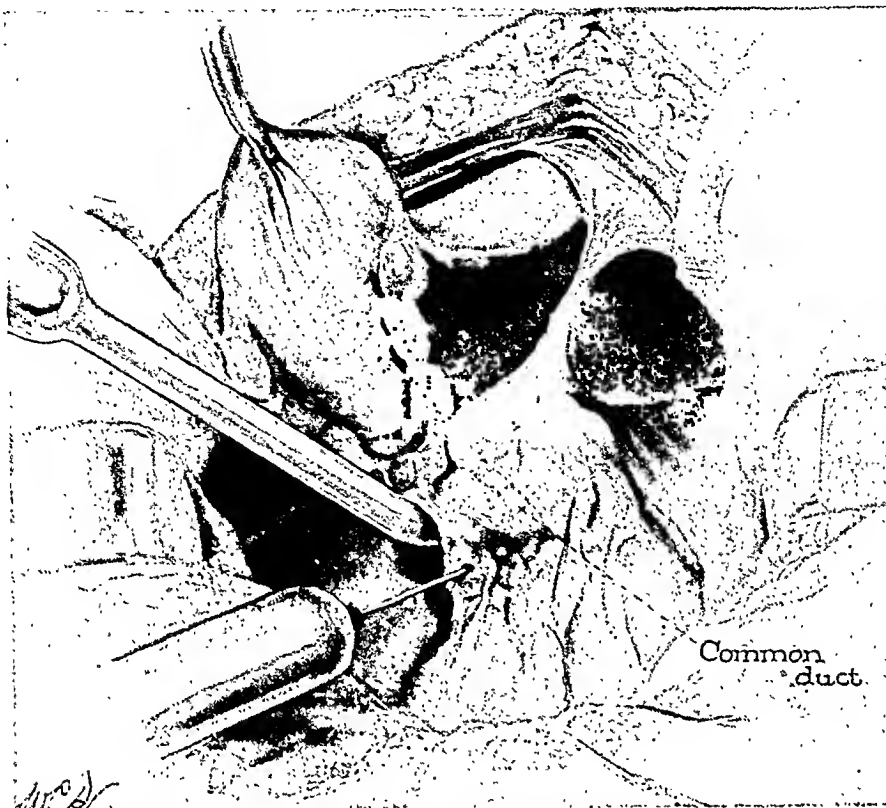
Fig. 3. Infiltration of gastrohepatic omentum. Transilluminator in place in the foramen of Winslow.

because of the characteristic sensation transmitted to the fingers when the needle pierces the fascia.

The area of deep abdominal wall infiltration is roughly triangular in shape, the base of the triangle being the upper linea alba, one side the right costal margin and the other side a line joining the two. An intra-dermal wheal is raised at a point 2 inches below the umbilicus just to the right of the median line and a line of subcutaneous infiltration is carried around the triangle and back to the starting point. The right costal margin is next infiltrated deeply into the muscular layer by a series of fan-like injections along the entire border. The same procedure is repeated along the medial side of the triangle, thoroughly flooding the sheath of the rectus muscle and continues across the abdomen to meet the lateral edge of the costal infiltration. Insufficient relaxation results most often

with gentle massage. Ten minutes after infiltration the field is insensible.

Incision is made through the right rectus fascia and muscle exactly as with a general anesthetic. The transverse fibrous intersections of the rectus muscle may need a few extra drops of anesthetic at this time. The posterior sheath of the rectus and peritoneum are insensitive to pain from cutting and may be incised without infiltration provided that crushing and traction is avoided. The gall-bladder presents itself anteriorly and by gentle manual retraction the stomach can be displaced to the left and the colon displaced downward, each being kept out of the line of vision by a moist strip. The nerve block produces a surprising degree of muscular flaccidity and the wound edges may be separated with very light retraction.

If cholecystotomy alone is to be performed a few drops of novocaine injected

into the subserous coat of the gall-bladder are all that is needed, whereas cholecystectomy requires the addition of visceral

block the deep sensory nerve supply by complementary splanchnic block. This is most simply done by lifting a portion of the
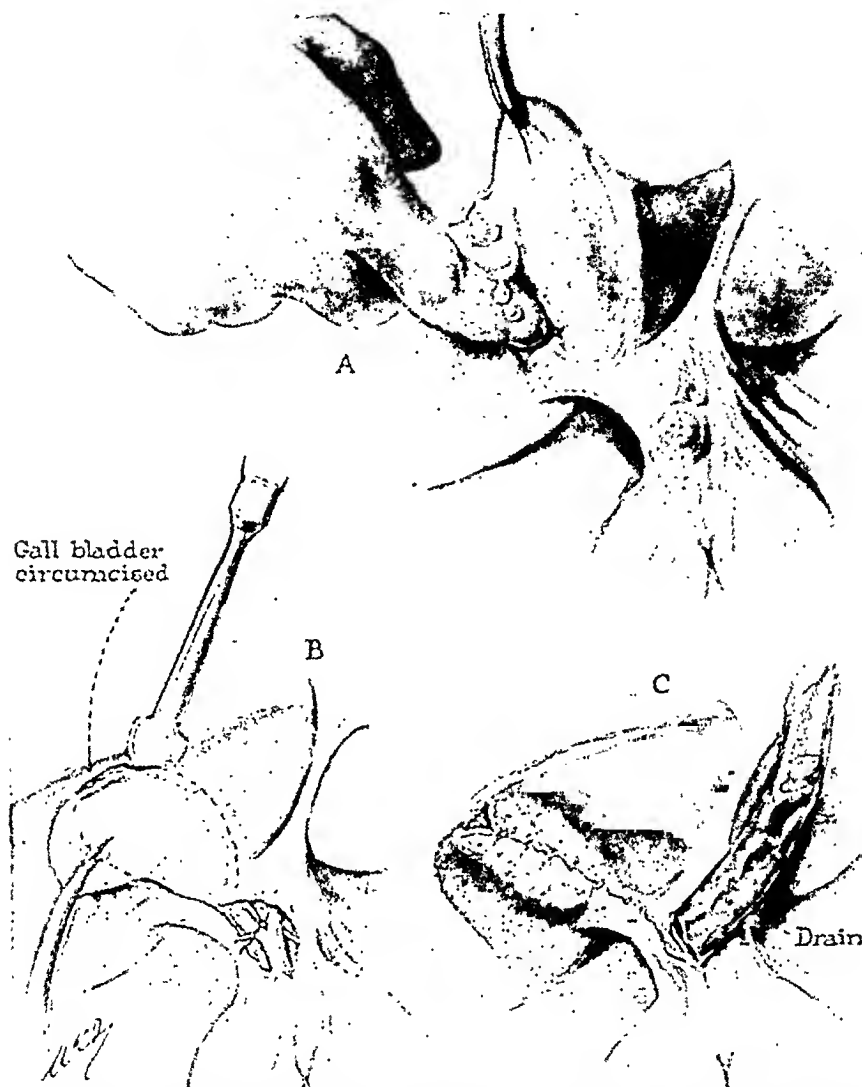
FIG. 4. A, dispersion of anesthetic solution by stroking. B, incision into the gastro-hepatic omentum, dissection and ligation of cystic duct and artery. C, closure of denuded bed of gall-bladder. Penrose drain in position.

anesthesia. This is induced by the injection of novocaine solution into the fold of the gastrohepatic omentum and by a circumscribed subserous infiltration of the entire attachment of the gall-bladder to the liver. The latter step has the advantage of acting as an effective means of stripping the gall-bladder from its bed and greatly facilitates its bloodless removal. In cases with extensive adhesions where traction must be used on the gall-bladder it is necessary to

uncut posterior parietal peritoneum in the infrahepatic fossa and injecting through a fine angulated needle 30 c.c. of novocaine solution behind the peritoneum. Care must be exercised to avoid injuring or injecting directly into the large vessels nearby. When injections have been made into the gastro-hepatic ligament, subserous layer of the gall-bladder and beneath the posterior parietal peritoneum, the anesthetic may be spread beneath the serous surfaces by

stroking with the fingers, thus increasing the area of effectiveness and avoiding the distortion due to an excess of localized fluid.

Cholecystectomy is then performed according to routine procedure by splitting the anterior margin of the gastrohepatic omentum and isolating the cystic duct and cystic artery, which latter is ligated and divided. A pear-shaped incision is then carried upward close to the attachment of the gall-bladder to the liver. The gall-bladder is separated from its bed by dissection with a semi-sharp spatula knife, leaving it hanging by its sole remaining attachment, the cystic duct. This structure is divided between clamps and the common duct explored by palpation with the index finger through the foramen of Winslow and by distal probing through the open end of the duct. Proximal probing into the hepatic duct is to be undertaken only with a knowledge of the danger of producing intrahepatic impaction of stone or of injury to the duct with possible immediate or late obstruction.

Wound closure is effected in layers with provision for drainage through a small separate stab wound incision.

SUMMARY

Local infiltrative anesthesia has a definite place in surgery of the gall-bladder and adds a factor of safety in those cases in which the use of general anesthesia would be expected to increase the hazard of operative procedure.

Cholecystectomy may be performed painlessly and rapidly when postural assistance is utilized and blunt dissection and heavy traction are avoided.

Cholecystectomy usually requires the addition of infiltrative visceral and splanchnic block.

Simplicity of apparatus and of procedure make this a satisfactory method for use by the general surgeon.
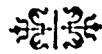
IODINE METABOLISM AND THE HYPOTHYROID STATE*

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SINCE Gull reported five cases of hypothyroidism in 1875 before the Clinical Society of London there has been varied usage of the term. In his patients there was a marked apathy and he did not refer to myxedema as associated with the disease. Ord in 1877 reported six cases with edematous infiltration of the skin and since then the late stages of hypothyroidism have been referred to as myxedema or Gull's disease.

The suppressed or diminished thyroid state frequently does not produce the classical or cardinal symptoms on which a diagnosis can be made. The terminal stage of the disease or myxedema is rarely encountered, as compared to the symptoms produced by the earlier stages of hypothyroidism. Thyroid dysfunction, whether it is a hyperactivity or a hypoactivity, is due to imperfect iodine metabolism. We know from the work of Marine and Lenhart[12] that the iodine content of the gland is inversely proportionate to the epithelial hyperplasia. Therefore in an exophthalmic goiter the iodine is lowest and in a colloid goiter it is highest. The iodine content of the normal thyroid is given as 0.3 per cent of the dried weight of the gland. The gland contains either the inorganic iodine or thyroxin, the organic compound, or both. It is known that thyroxin is 65 per cent iodine.

In thyroid dysfunction it is necessary to consider iodine metabolism. We know that iodine is the one medication that will prevent adolescent and colloid goiter when sufficiently administered in the endemic goiter belts. Kimball[9] has recently given figures from the State of Michigan where the incidence of goiter in sections studied by him was 38.6 per cent in 65,537 children

examined and after four years by adequate administration of iodine the incidence was 9.9 per cent in 50,134 children. In the non-goiter belts there is a definite percentage of thyroid disease that cannot be attributed to a diminution in the iodine content in the food or water. It is necessary to seek further for an explanation why these patients develop goiter. As the iodine ultimately unites with tyrosine, which is the end product of protein metabolism, to form the active principle of the gland, it may be that a disturbance in protein metabolism is an important factor in producing both hyper- and hypothyroidism. For that reason it would seem worthwhile to go into a more detailed discussion of the mechanism of the iodine and protein metabolism.

Since 1895, when Baumann discovered the presence of iodine in the thyroid gland, it has been known that iodine was in some way associated with thyroid activity. The site and the mode of action were not understood, until Marine and Lenhart[12] in 1909 proved that iodine, when administered to dogs, would produce rapid involution in the gland. In 1915, Kendall[8] isolated the active principle of the gland and called it thyroxin. Harington and Barger[5] in 1927 synthesized this substance from tyrosine. Sweet and Ellis[16] in 1915, while trying to determine whether dogs could live after ligation of the external ducts of the pancreas, noticed that the thyroids of these animals became quite translucent and that a type of colloid goiter was produced. The iodine content of these glands was increased. No explanation was given for this phenomenon.

It seemed to the author and his two co-workers[2] that the work of Sweet and Ellis was very significant in explaining the

metabolism of iodine. In the light of the work on the chemistry of thyroxin, it seemed possible that a lack of trypsin in the intestinal tract, under which condition the proteoses and peptones might not be hydrolyzed completely to amino acids, would explain hypothyroidism and possibly hyperthyroidism. From our experiments it seemed that the normal supply of tyrosine was not available in the thyroid for the formation of thyroxin. The relationship between thyroxin and tyrosine may be seen from their structural formulae:

FORMATION OF THYROXIN FROM TYROSINE
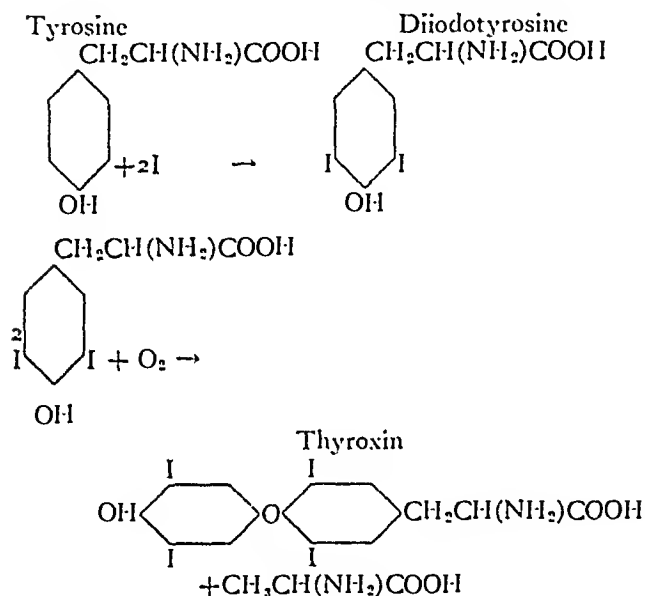
Also, it is to be expected that the iodine content of the gland would be increased after ligation of the pancreatic ducts because there would be less tyrosine present to mobilize it in the form of thyroxin, and hence the iodine would be deposited in the gland. This we proved by our experiments on dogs.

If a diminution in the tyrosine supply is a factor in the development of a colloid type of goiter, then perhaps, an excessive formation of tyrosine or an allied chemical substance, such as tyramine or phenyl-alanin, might result in the development of toxic goiters.

Tyramine is easily formed from tyrosine by carboxylation in the following manner:

FORMATION OF TYRAMINE FROM TYROSINE
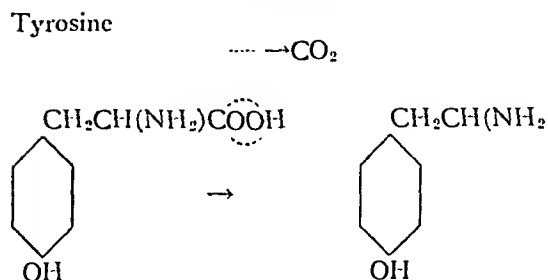
In the body tyramine is known to be produced normally in small amounts by certain strains of colon bacilli. In a series of very thorough investigations, Hanke and Koessler[4] have shown that there are two separate strains of colon bacilli containing carboxylase—one forming histamine from histidine, the other forming tyramine from tyrosine. Both are active in this way only in an acid medium, probably as a protective mechanism. The latter strains form phenols from tyrosine in the more alkaline medium usually prevailing in the intestines. The physiologic effect of histamine is known to be antagonistic to that of tyramine; therefore, variations in the proportions normally formed might give rise to systemic disturbances. Various animal species seem to differ in the absorbability of these substances, but Coyle and Boyd[1] have shown that tyramine is quickly taken up from the large intestine of the dog, less quickly in the cat. The concentration of tyramine in the blood of humans supports the idea that it may be absorbed from the intestines, since that is the only known site of formation. It seems improbable that tyramine could be formed elsewhere in the body, except as a result of bacterial activity, since such a decarboxylating mechanism is not yet known and would involve an entirely new mode of catabolism for the amino acids.

For a number of years McCarrison[13] has claimed that thyroid disturbances are at least partly intestinal in origin. On administering tyramine to dogs, rats and pigeons, he noted the usual physiologic effects, similar to those of hyperthyroidism, but the gland was, if anything, diminished

in size and little changed histologically. He states that the ingestion of tyramine may cause exophthalmos, but that it is of rare occurrence.

Thyroid dysfunction may result either from a lack or an excess of the substances from which the active principle of the gland, thyroxin, is formed. These substances are tyrosine and iodine. An excess of tyrosine and a diminution of iodine might result in a form of thyroxin containing less iodine than normal, and a type of hyperthyroidism would be produced. If, on the other hand, not enough tyrosine was available to mobilize the iodine, a colloid type of goiter might result or there could be hypothyroidism without thyroid enlargement. Such disturbances could be brought about by intestinal disorders, dietary irregularities, scarcity of iodine in the diet, or dysfunction of the tissues normally responsible for oxidizing excess of tyrosine. Either an excess or an abnormal side product of the amino acids would be found in the latter case.

The histologic picture of normal thyroid should be considered before referring to the pathologic picture of the underactive gland. Kimball[9] gives 0.5 Gm. of thyroid per kilo of body weight as normal, i.e., a total of 20 to 35 Gm. of thyroid for a normal individual. After a study of human thyroids, it soon became apparent that the teaching of the normal histologic picture was based on insufficient data, and it was therefore obvious that conclusions as to the pathologic picture of the gland were likely to have different interpretations in the hands of different pathologists. The sections studied[6] were taken from humans meeting with accidental death and apparently in normal health at the time of the accident. All ages from stillbirths to those in the ninth decade were studied. This work has been reported in detail.

More recently I have had an opportunity to study normal dogs' thyroids while doing experimental studies[7] under Dr. Joshua Sweet in the Department of Experimental Surgery of Cornell Medical School. The histologic findings correspond to the human in that they represented a most bizarre histologic picture. I feel that one cannot determine the normal human thyroid by basing an opinion on the microscopic picture of the gland alone unless the studies are from serial sections of the entire gland. One would, accordingly, expect different opinions as to the normal physiologic state of a patient.

The thyroid secretion for a given individual must remain at a relatively constant level for normal health to be maintained. Kimball[9] recently stated that iodized salt is an efficient and safe method of preventing simple goiter, but stresses that the salt must have one part of potassium iodide to five thousand parts of salt. The incidence of goiter in Michigan was 38.6 per cent in 1924 before the salt was used. After a four year period of salt administration the incidence fell to 9.9 per cent in 1928.

The terminal stage of hypothyroidism or myxedema is well known and need not be elaborated upon, but the early stages of hypothyroidism produce most bizarre symptoms and for that reason the condition is frequently overlooked. It is known from the work of Sharpe and Bisgard[15] that complete removal of the thyroid in rabbits causes them to develop a macrocytic anemia. We know from the work of Emery,[3] Mackenzie,[11] and Lerman and Means[10] that anemia is also frequently found in patients with hypothyroidism. Schwanke[14] reports that 60 per cent of patients with exophthalmic goiter have a polycythemia, with the erythrocyte count between five and eight and one-half million. This makes one wonder if hypothyroidism may not frequently be the forerunner of both acute respiratory infections and secondary anemia. A very common complaint of a patient is that he has been "anemic" and under the care of a physician for same.

The clinical problem in hypothyroidism is provided by the vague symptoms so commonly attributed to some other organ or organs. To diagnose early hypothyroid-

ism is difficult, but one should suspect it when patients present the following complaints: dry skin with falling hair or baldness; apathy; general weakness; and nervousness, when fatigued, i.e., coming on late in the afternoon or early evening. Somnolence and constipation are common complaints. The laboratory aids are, of course, a basal metabolism reading and the cholesterol determination. It is at times necessary to treat a patient as a hypothyroid, although the metabolism may be reduced only to the lower limits of normal, if one is clinically certain of the diagnosis. At times most astounding results are encountered in these patients.

The lassitude is more marked on arising in the morning, improving during the middle of the day and returning in late afternoon or evening. Abdominal pain is frequently associated, with the period of lassitude, as are mental depression and irritability. The abdominal pain of the hypothyroid patient may be fairly typical of a peptic ulcer, but the periodicity is lacking. A long vacation with complete rest will frequently cause the symptoms to improve, but under the ordinary stress and strain of daily activity there is rarely any periodicity in the abdominal symptoms of the hypothyroid. Vomiting is occasionally encountered, usually when the patient is extremely tired.

A definite group of patients has peptic ulcer which cannot be demonstrated by roentgenologic examination. These patients give a typical ulcer symptomatology with periodicity perhaps extending over years with the intervals of freedom from pain becoming shorter and the severity of the pain gradually increasing. This type of patient obtains definite relief from a Sippy régime. The hypothyroid patient, however, rarely shows any improvement on an ulcer diet, in spite of ulcer symptoms. Obviously, not all patients suffering from ulcer symptomatology with negative x-ray findings have definite hypothyroidism. Yet some do, and if one is careful to evaluate the symptoms of hypo-

thyroidism these cases can be diagnosed. A basal metabolism will usually verify the diagnosis.

The treatment should consist of thyroxin (1 mg.) intravenously once a week, with thyroid extract, gr. 1, orally twice or three times a day. It is important to continue the thyroxin administration intravenously at weekly intervals over a relatively long period of time, i.e., from eight to ten weeks. This may be governed by the clinical course of the patient. It is rare that any improvement is noticed in the symptomatology before four to six weeks have elapsed and it is therefore well to inform the patient that he will probably not have any benefit under a six weeks' period.

It would seem from the experiments on animals and the clinical results obtained from thyroxin administration that the therapeutic effects lies in the tyrosine radical of the molecule and not in the iodine content of thyroxin.

Treatment must be carried on for a long time, the metabolism should be checked at least twice a year, and the thyroid and thyroxin administration governed according to the clinical course and metabolic findings. After the patient is symptom-free and his metabolic determination normal, he must be made to realize that this state will not continue unless thyroid medication is taken at intervals over a period of months and perhaps years. Dietary regulations are not necessary and other medications, such as sedatives, are rarely administered. The improvement is due to a general stimulation of the metabolic processes. In patients who will not tolerate thyroid by mouth, thyroxin tablets, $\frac{1}{80}$ or $\frac{1}{60}$ gr. twice a day may prove very beneficial.

SUMMARY

The bizarre types of hypothyroidism apparently are due to the inability of the individual to metabolize iodine rather than to a true iodine deficiency. It would seem to be the organic radical of the thyroxin molecule that is at fault, as clinical

experience tends to support this view. For that reason much better results are obtained by the intravenous use of thyroxin, supplemented with thyroid extract by mouth. After the metabolism is elevated to normal, the thyroxin should be discontinued and the normal level maintained by oral administration of thyroid extract.

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LOW BACK PAIN AND SPINA BIFIDA OCCULTA

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THE subject of low back pain has, in recent years, received attention from and stimulated the interest of numerous investigators. An immense amount of literature has accumulated, demonstrating a large variety of theories and a conspicuous diversity of opinion with regard to the causes of the ailment, the mechanism of production of symptom complexes, and the forms of treatment. The foremost conceptions of this affliction are well known to students of the subject and require no review.

It should be mentioned briefly that, according to current theories, practically all the structures that comprise the region of the lower back have, at various times, been blamed as the source from which the pain arises. These include bones, joints, muscles, ligaments, fascia, nerves and, if necessary, the specialized tissues of the nucleus pulposus with its adjacent structures. The principal agents which have been accused or suspected as causes are trauma, inflammation, tumors, infection, posture and degeneration. The effects of these agents upon the supposedly vulnerable structures result in arthritis, osteitis, myofascitis, nerve compression and herniation. In some manner, not always easy to understand, the symptoms and physical signs appear in many forms and combinations to represent what is commonly called low back pain.

It is realized that the construction of the human body is such that any or all of the component parts of that region may enter into the production of pain; that pain may be extremely variable in location, intensity and extent, depending on the structures or tissues which are affected and the method by which the effect is produced. Added to this thought is the generally accepted notion that the lower back constitutes, in a mechanical sense, one of the most unstable mechanisms of the human body. This is customarily attributed to phylogenetic peculiarities and weaknesses in a part of the body which has in man not yet become sufficiently stable to meet the strains which are imposed on it.

It is at once obvious that no single theory, however well founded it may be, will suffice to explain all the situations which may be included within the range of the general term, low back pain. However, excluding the relatively small proportion of cases of this nature in which the symptoms are indisputably attributable to specific disease processes, there remains that vast majority of cases in which no accurate information is available on the etiology, pathology and pathogenesis. This constitutes the group of disabilities for which an explanation is sought in this analysis.

The object of this presentation is to establish a relationship between low back pain and spina bifida occulta. The material available for study consists of seven cases on whom operation was performed for relief of symptoms.

Spina bifida occulta is a congenital malformation of the spine, consisting of a faulty development of portions of the spine, usually the laminae. This malformation may assume several different forms. It may present itself as a cleft or incomplete fusion of the laminae; it may appear as a defect of the bone between adjacent laminae; it shows considerable variation in size and shape; it may be on one or both sides of the midline; it may be single or multiple. It is most commonly situated in the upper three sacral laminae. The term spina bifida occulta may be applied to any congenital

defect in the laminae of the upper sacral vertebrae. It is, contrary to general belief, relatively rare in the fifth lumbar vertebra.[1]

The importance of spina bifida occulta lies in its constant association with pathologic alterations within the spinal canal. These consist of masses of fibro-adipose tissue, overlying the dural sac and the nerve roots in the sacral canal. In addition, cords of fibrous tissue are found extending between the ventral surface of the laminae and the dura or the nerve roots. Both of these features are, by virtue of their construction and arrangement, capable of producing a mechanical irritation of the nerves sufficient to interfere with their function.[2]

SYMPTOMATOLOGY, TREATMENT AND RESULTS

For the purpose of this discussion, it is intended to adhere to the customary division of pain with radiation and that without radiation. In this series, all of the cases were of the former type.

From a study of the relatively few patients which form the basis of this analysis, it is evident that most or all of the subjective and objective manifestations can be attributed to changes in the muscles or tendons. The pains which form the patient's complaint can, in most instances, be reproduced by palpation of the muscles. Invariably the tenderness which is discovered by such examination is much more extensive than the history of the disability indicates. Thus it is possible to find areas of tenderness in many of the muscles or groups of muscles, not only in the regions where the patient is subjectively aware of them, but also in other sites where there was no suspicion of such findings. The favorite locations of tenderness are the upper portion of the sacrum in the midline and at either side of the midline, the gluteal muscles, the tensor fasciae latae, the iliotibial band, the gastrocnemius-soleus group, the peronei and extensors of the toes and the short plantar muscles of the foot. This form of tenderness is, as a rule, localized and limited to certain small areas of the muscle substance or the tendon, the rest of the muscle being quite normal in that respect. There is, in some cases, a very definite tenderness of the lumbar muscles, most prominent in the sacrospinalis. Further, the same findings may be noted in a less severe form, in the thoracic portion of the spine, the scapular muscles and some of the muscles of the upper extremity.

The findings in the muscles are usually bilateral, even though the symptoms are more prominent on one side or entirely confined to one side of the body. Tenderness is neither common nor severe in the hamstring muscles, the quadriceps femoris or the adductor muscles of the thigh. In those muscles in which tenderness is elicited, it is possible to detect muscle spasm, evident from the firmness of the muscle substance and the limitation of motion in the joints.

The tendon reflexes in the lower extremities are usually disturbed. The knee jerks and the ankle jerks are most often absent or diminished in their reaction, though they may be normal.

Limitation of motion is undoubtedly due to muscle spasm, which in turn is the result of reflex contraction of the muscle to avoid pain in stretching. This is illustrated in the restriction of straight leg raising movements, which is probably the result of spasm of the gluteus maximus.

There is reason to believe that the term "sciatica" is a misnomer. While undoubtedly, as will be shown, the pain in this disorder is primarily the result of nerve irritation, it is believed that the tenderness of the sciatic region in the thigh is, in reality a tenderness of muscle or tendon. In this connection, it is most probable that the pain so produced is in the hamstring muscles, the gluteus maximus or the portion of the fascia lata into which the gluteus maximus is inserted. Even more convincing that this is not a nerve tenderness is the observation that, in the presence of tenderness in the peronei, no tenderness can be found in the peroneal nerve.

It will be noticed that the clinical picture is very similar, in all its important aspects, to the form of muscular rheumatism which has been found in younger individuals where it affects more frequently the muscles of the legs and feet. The principal difference is the location of the chief symptoms.

Among the patients here studied, there were four males and three females, all of them presenting the picture of low back pain with radiation. The ages varied from 29 to 47 years. The duration of symptoms ranged from six months to fifteen years.

In all of them a combination of symptoms and signs, characteristic of muscular rheumatism, was found. This was evident from the presence of muscle tenderness, muscle spasm, limitation of motion, disturbance of reflexes, excessive fatigue on exertion and pain which was present more or less constantly. In five there was a history of constipation extending over a period of years and necessitating the use of cathartics.

The extent of their disability may be illustrated by the statement that five of the patients were bedridden for periods of three weeks or more previous to administration of treatment; the other two, though ambulant, were unable to perform their customary work.

The roentgenologic changes seen in the sacrum were very uniform and consisted of defects in the laminae of the upper sacral vertebrae. There was no evidence of a spinal cleft, such as is more commonly seen in children and adolescents. The laminae were united in the midline and small defects were visible on either or both sides of the midline. (Figs. 1 and 4.)

The pathologic changes in the spinal canal were typical in all cases but one. In this the nerves distal to the dural sac were matted together by firm fibrous tissue. A few small particles of fat tissue were found overlying the nerve roots, but for the most part, it seemed that any nerve disturbances which might originate from these changes were the result of conditions which at the time were considered irreparable. Added to this fibrosis was the presence among the fibrous tissue of several veins, somewhat dilated and tortuous, thin-walled and friable. In all the other cases the characteristic alterations were found.

Spinal fluid obtained at operation in five cases was clear, showed cell counts of 15, 49, 95, 200 and 730 per c.mm.

The operative procedure consists of a laminectomy of the upper three sacral segments and removal of the pathologic structures within the canal. Of the seven patients so treated, three, all males, are entirely free from their former symptoms. They have been under observation for fifteen to seventeen months since operation. Two have returned to their work as laborers; the third spent three months after operation in recovering from his disability, but is since that time completely relieved and able to participate in activities, such as playing baseball and hunting. Three other patients, all females, are improved in the sense that their muscular pain and tenderness have been eliminated. The period of observation since operation ranges from seven months to eleven months. They are better able to carry on their activities, though they are still somewhat disabled by conditions which are clearly in no direct relation to the sacral nerves. In one case in which the findings at operation were atypical and apparently beyond repair, there was no change.

CASE REPORTS

Case I. G. J., age 36, white, male, was seen on April 16, 1936, complaining of pain in his back and right hip. Symptoms began in December 1935, when he first noticed a "catch" in his right hip in stooping over. While at work as a laborer, he developed a severe pain in the right gluteal region. This radiated sharply to the outer aspect of the leg, and was produced by bending forward. Pain subsided when at rest. He had no relief from medicines or counterirritants, could not perform steady work or heavy work, and at one time he was confined to bed for three weeks, on account of pain. His hands become numb very easily

when he drove a car or used a shovel, so that about every five minutes he had to rub them or activate them in order to restore normal sensation.

Examination revealed a list to the left and a mild atrophy of the right gluteal region. Forward flexion of the spine was definitely restricted and produced a sharp pain in the lower portion of the right gluteus maximus. If carried further, the pain radiated to the leg and foot. Bending backward and to the left were free. Pressure tenderness was noted in the lumbosacral region and in the lower part of the gluteus maximus.

X-ray showed a small defect on the right in the first sacral lamina; another on the left in the upper portion of the second sacral lamina. Both were oval in shape, smooth in contour and dimly outlined against the background of the bodies of the sacrum. (The findings as shown in the print are too dim for accurate reproduction. In general they are similar to those in Figs. 1 and 4.)

The patient was seen again in August 1936. He had during the interval been engaged in various types of manual labor. He had pain in the lower back and right leg more or less constantly, whether he was working or resting. Ten days previously he had been drenched in a rain and this aggravated his condition so that he could not sleep at night. For the three days and nights he had not slept more than ten minutes at a time, and this was accomplished after administering $1\frac{1}{2}$ gr. of morphine. The right leg was painful and numb, and the right ankle was hot and swollen. On measurement his right ankle showed a circumference one-half inch less than his left.

It was also ascertained that he had headaches frequently. These were associated with an obstinate constipation extending over a period of many years.

Examination revealed definite tenderness of the sacrum at various points and on both sides of the midline at that level. In the right gluteal region there was very severe tenderness in the middle portion of the gluteus maximus. Further tenderness was elicited at different points in the upper third of that muscle. In addition, tenderness was found in the tensor fasciae latae, the iliotibial band, the gastrocnemius and peronei in the leg and the short flexors and extensors of the foot. The findings on the left

were very similar in distribution though not so marked. There was no tenderness of the peroneal nerve on either side.

Dorsiflexion of the foot was painful. Straight leg raising was restricted at 30 degrees on the right and at 40 degrees on the left. The right knee jerk was absent, the left was slightly active but irregular. The ankle jerks were absent and there was no ankle clonus or Babinski sign.

Operation on August 22, 1936, consisted of removal of the laminae of the first, second and part of the third sacral segments. No defects were noted in the bony structures. From the ventral surface of the second sacral lamina, two heavy cords of fibrous tissue were seen proceeding cranially to be attached to the dura laterally at the level of the first sacral segment. These cords were irregularly flat on cross section. Several small particles of fat tissue were removed from the nerves lateral and distal to the dural sac. The spinal fluid was clear and contained 49 cells per c.mm.

Dr. C. A. Hellwig reported the pathologic findings as follows: "The specimen consists of three small masses of hemorrhagic fat tissue. Microscopically, the masses of fat tissue are divided into lobules by fibrous tissue septa. In several areas, fibrosis is noticed. No inflammatory cells are found. There are a few brownish iron pigment granules and many red blood cells in the fat tissue."

For about seventy-two hours after operation the patient had severe pain in his back and right leg. Beginning with the fourth day, he had much less pain, was able to sleep and to assume positions in bed which previously were impossible due to pain. Four weeks after operation he was entirely free from pain. The numbness of the leg and foot had disappeared. He had free movement of the back and both lower extremities. He had been doing work about the home and stated that he could do light work continuously for three hours without any of his former symptoms.

He volunteered the information that his hands no longer become numb when he is using implements. His feet felt warm and more comfortable. He had regular bowel movements without the use of laxatives. On examination, he showed a mild tenderness of the right gluteus maximus. Straight leg raising was possible to 60 degrees on the right and to 75 degrees on the

left. Knee jerks were regularly obtainable though not normally strong.

He has been seen at intervals for fifteen

Fig. 1. Case ii. Roentgenogram of lumbosacral region showing defect of bone in the second sacral lamina on both sides of the midline. Immediately below the spinous process of the first sacral segment, at the right of the midline is a round area several millimeters in diameter, in which the defect is complete throughout the entire thickness of the lamina.

months after operation, and has never had any recurrence of his former symptoms, even though he has engaged in hard manual labor. He stated that he had worked for a number of days in the harvest fields, on some days spending twelve hours at this type of work, without more than the ordinary amount of fatigue or discomfort.

CASE ii.   Mrs. F. L., age 26, white, was seen in December 1936, complaining of pain in the lower part of her back and the right hip and leg. About eleven years previous she was thrown from a horse, and although she was not injured, several months later she noticed a sharp pain in her back when twisting her body. Some years later she noticed that the pain radiated to the right hip, but was not severe or constant. Two months before she was examined the pain appeared in the right buttock and radiated to the lateral aspect of the leg. Since then it had become gradually more pronounced, and for the three weeks it had been

present continuously, regardless of activity or position of body. During that time she had been confined to bed.

Fig. 2. Case ii. Photograph showing ventral surface of laminae, with several fibrous cords attached. Nearby are shown specimens of fat tissue removed from sacral canal. The length of the bone specimen was 6 cm.

She had had headaches all her life, sometimes for three days a week. These were at times associated with numbness of the fingers, hand and arm on the right side, and occasionally with partial blindness of the right eye. She used laxatives constantly until several years before. Previous to the birth of her child, sixteen months previous, she had always had severe cramping pain for two or three days preceding menses. Since that time, menstrual pain had been slightly less severe.

The patient walked slowly with a limp on the right. Her feet were abnormally cold though not discolored. The right hip was maintained in a position of slight flexion. In the region of the anterior superior iliac spine on both sides the skin showed atrophic striae. Straight leg raising was restricted on the right at 35 degrees and on the left at 45 degrees. Tenderness was elicited in the upper part of the sacrum and on both sides of the midline at that level; on the right in the gluteus maximus, the tensor fasciae latae, the gastrocnemius, the short flexors of the toes and the short extensor of the toes; on the left only in the gastrocnemius. It was most prominent in the lower portion of the right gluteus maximus, where it was possible to reproduce the pain which the patient experienced subjectively.

Knee jerks and ankle jerks were exaggerated on both sides and there was a mild ankle clonus on each side.
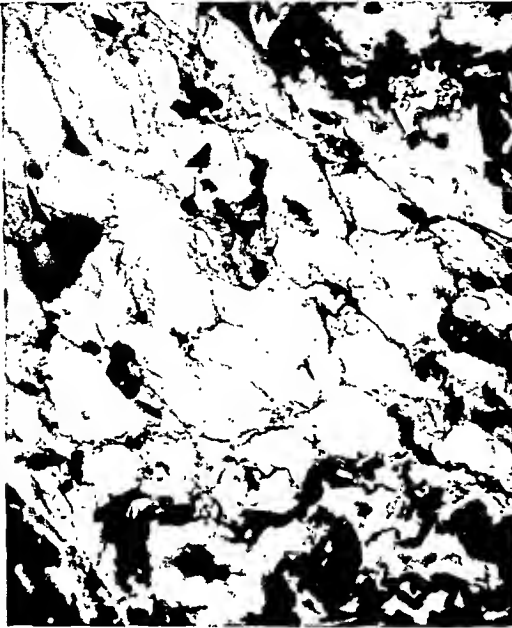
FIG. 3. Case II. Photomicrograph of fat tissue, showing fibrosis. In addition there was evidence of round cell infiltration and old hemorrhage.

Roentgenographic examination showed a bony defect in the upper portion of the second sacral lamina on both sides of the midline. (Fig. 1.)

At operation, December 4, 1936, the laminae of the first and second sacral vertebrae were removed. On the ventral surface of the laminae, a number of bands of fibrous tissue were found, extending to the contents of the canal. (Fig. 2.) In addition a layer of fat tissue was seen to cover the lower end of the dural sac and the nerve roots. This was removed in small fragments. (Fig. 2.) Spinal fluid, obtained at operation, was clear and contained 95 cells per c.mm.

Dr. C. A. Hellwig reported on the tissue: "In the specimens of fat tissue, there are areas of dense fibrous tissue. There are a few leucocytes and areas showing deposits of old blood pigment." (Fig. 3.)

Recovery from operation was favorable. After four or five days the pain was decidedly less intense. The patient continued to improve and was discharged from the hospital on the twelfth postoperative day. Since then she has been free from the pain for which she was treated. She resumed her activities at home. During four months following operation she gained 19 pounds in weight. There was a noticeable decrease in the intensity of menstrual pain. There was a mild tenderness of the

FIG. 4. Roentgenogram of lower spine in female patient, age 36 years. Had pain in back for fifteen years. Shows bony defect in lower part of first sacral lamina, and encroaching on spinous process at left of midline. A similar, though less conspicuous, defect is seen in the lamina of the second sacral segment, immediately to the left of the midline.

gastrocnemius on the right though she has no subjective pain. While she is much more able to perform her household tasks, she still has mild discomfort and a tired feeling in the muscles of her back, which affects the muscles of the lumbar region of the spine. There was no change in the intensity of headaches, in the frequency of attacks of numbness in her fingers and hand, or in the tendon reflexes. Straight leg raising is possible to 80 degrees. These findings represent her condition, ten months after operation.

DISCUSSION

From the analysis of the cases the most important feature is the demonstration of the pathologic changes in the spine. These can very certainly be considered as essential factors, or probably the actual cause in some cases of low back pain. This conclusion is justifiable in those instances in which complete relief is obtained by eradicating them. In the cases in which symp-

tomatic relief is not complete, it is noted that whatever disability is not influenced, is clearly not attributable to any disturbance of function of the sacral nerves. The most gratifying aspect of this form of treatment is the regularity of disappearance of the most serious symptom—pain. Coincident with such relief is a greater freedom of muscle action and in some instances a subsidence of certain visceral disorders, the most prominent of which is a spastic constipation.

In some patients there is a certain amount of residual disability, consisting of a weakness, with or without a moderate degree of pain in the paraspinal muscles of the upper lumbar region. This condition may or may not be of importance to the patient or the physician, previous to treatment. After treatment, however, when the most conspicuous symptoms have been corrected, such handicaps become more prominent. From a study of such patients, it is most probable that the clinical features which remain are caused by a similar form of pathologic change in the spine, and situated at a higher level in the spinal canal.

SUMMARY

A study is made of seven cases of low back pain with radiation. Most of these, at the time of treatment, were bedridden and all were handicapped in their activities. Low back pain with radiation is, in some instances, manifested by clinical findings which are confined to the muscles. These consist of tenderness on pressure, pain on stretching and muscle spasm with the resulting limitation of motion in the joints. This symptom complex, characteristic of muscular rheumatism (Port) was noted in all of the patients in this series.

Associated with the muscular symptomatology are congenital defects of the sacrum which are identified as spina bifida occulta. Bony anomalies of this type are invariably accompanied by pathologic alterations within the spinal canal. These consist of masses of fat and fibrous tissue, in close contact with the nerve roots in the canal, and so arranged that a mechanical irritation of the nerves is produced.

Treatment consists of surgical removal of the offending tissues from the canal. By this procedure a prompt cure or improvement may be obtained in a high percentage of cases.

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CASE REPORTS

PRIMARY CARCINOMA OF THE GALL-BLADDER*

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IN reviewing the literature on carcinoma of the gall-bladder it becomes apparent that this subject has received relatively little attention. The first twenty volumes of Index Medicus (from 1927 to 1936 inclusive) list less than 100 references to this subject in all its phases. In this communication we propose to show that this disease is not as uncommon as is supposed and that it is amenable to surgery.

The cases reviewed in this paper were taken from the records at the Jewish Hospital for admissions between 1932 and 1936 inclusive. During this period there were thirty-one cases of carcinoma of the gall-bladder admitted to the hospital of which number twenty-seven were subjected to surgical intervention. The incidence of this disorder in all admissions to the hospital was 0.04 per cent and in surgical gall-bladder cases 2.5 per cent. (Table 1.) This disease constitutes 0.6 per cent of the autopsy material and 4.4 per cent of the carcinomata seen at necropsy.

Illingworth[1] at the Edinburgh Royal Infirmary noted thirty-six cases of primary carcinoma of the gall-bladder in 8,490 autopsies. During this period there were 1,275 cases of malignant disease at autopsy. Carcinoma of the gall-bladder therefore accounted for 0.42 per cent of all autopsies and 2.8 per cent of all malignancies seen at necropsy. This same author quotes Wilkie as having a 2.2 per cent incidence of carcinoma of the gall-bladder in 1,057 operations on the biliary tract. Graham[2]

reviewed the work of von Berencsy and von Wolff who reported 19,908 necropsies. In this series there were 2,214 carcinomata of which number 300 (1.5 per cent) were carcinoma of the gall-bladder. Kaufman[3] states that "according to observations in

TABLE I

	1936	1935	1934	1933	1932	Total
Number of cases admitted........	15,269	14,616	14,988	14,909	14,261	74,043
Number of all carcinoma cases admitted.........	394	401	337	357	345	1,834
Number of all autopsies excluding new born.......	171	226	255	228	194	1,074
Number of all carcinoma cases at autopsy........	29	42	37	31	19	158
Number of surgical acute and/or chronic cholecystitis cases with or without calculi..	247	200	190	208	233	1,078
Number of surgical cases of carcinoma of gall-bladder........	5*	6*	8*	3	5	27
Number of autopsies for carcinoma of gall-bladder........	2*	1*	2*	2	0	7

* One surgical case came to autopsy in 1934, 1935 and 1936.

Breslau it occurred in 5 per cent, according to those at Basel 5.19 per cent and according to Gottingen over 7 per cent of carcinoma cases autopsied." Smithies[4] in 1,000 consecutive cases of gall-bladder disease found that twenty-three (2.3 per cent) of the cases had primary malignant disease of

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the gall-bladder. Judd and Gray[5] in 22,365 operations on the gall-bladder and biliary ducts found 212 primary carcinomata of the gall-bladder—a surgical incidence of less than 1 per cent.

Like carcinoma elsewhere in the human this is distinctly a disease of cancer age. In the cases presented in this paper the youngest patient was 51 years of age and the oldest was 77 years. Over 60 per cent of the cases occurred between 54 and 63 years of age. Fifty-six per cent of the female cases occurred before 60 years of age whereas only 16 per cent of the cases occurred in the male before that age. Illingworth reports that the greater majority of his cases occurred between 50 and 65 years of age.

Cancer of the gall-bladder, like the inflammatory disease of the gall-bladder, is more common in the female than it is in the male. In our cases it occurred twenty-five times in the female and six times in the male—a ratio of 4 to 1. Illingworth reports a sex incidence similar to ours. Judd and Gray report an incidence of 3 to 1, Ewing believes that the ratio is 4 or 5 to 1. Rolleston and McNee,[6] reviewing the Registrar General's returns in England and Wales from 1913 to 1920, found 2,296 cases of carcinoma of the gall-bladder in females and 946 in males—a ratio of approximately 2.5 to 1.

ETIOLOGY

Various etiologic causes have been ascribed to carcinoma of the gall-bladder, the most common one being foreign bodies (calculi) within the gall-bladder. Experimentally, Kazama[7] and later Leitch[8] were able to produce carcinoma by the introduction of various foreign bodies into the gall-bladder. They employed pebbles, suture material, mucous membrane from the gall-bladder, lanolin and gallstones. Clemente[9] did the same with tar. Delbet and Godard[10] used calculi taken from patients with the disease. All they could observe were hyperplastic changes in the wall of the gall-bladder but no neoplastic changes. Burrows[11] repeated the latter

experimental work, using stones from non-cancerous patients. He too was unable to produce malignancy of the gall-bladder. He did observe proliferative changes in the elements of the gall-bladder which macroscopically appeared malignant but microscopically presented none of the characteristics of malignant disease. His experimental work suggests caution in accepting the result of his predecessors and the theory that gallstones are the causal agents of carcinoma of the gall-bladder. Shelley[12] reports a case in which a piece of tape was left in the gall-bladder for eighteen years. The gall-bladder was subsequently removed and examined microscopically. No evidence of malignant change could be found.

Clinically it has been repeatedly observed that carcinomatous gall-bladders frequently contain calculi. In our own cases nineteen contained stones, six did not and in six cases there was no mention whether stones were present or not. Thus, 76 per cent of the known cases contained calculi. Judd and Gray report calculi present in 64.6 per cent of the gall-bladders with malignant disease, Musser[13] in 69 per cent of the cases and Courvoisier[14] noted it in 91 per cent of his cases. The presence of stones even in so high a percentage of the cases does not necessarily make that the causal agent. May it not be that the selfsame agent which causes carcinoma of the gall-bladder leads to the formation of calculi and that, gall-bladder calculi and carcinoma of the gall-bladder are due to concomitant changes in the mucosa?

PATHOLOGY

Macroscopic. The gall-bladder may be enlarged and present a nodular appearance —single or multiple. Or, it may be diffusely infiltrated and feel hard. In other instances it may appear normal to all intents and purposes except for a small local area of induration. When cut across, the wall is thickened and the lumen may be encroached upon by the nodular growth or by a papillary neoplasm. In the papillary form

there may be present a degenerating villous growth occupying the greater part of the lumen of the gall-bladder. Not infrequently the neoplasm extends outwards and into the wall of the gall-bladder as an intramural local mass. Within the gall-bladder there generally are some calculi and bile-stained mucopurulent material or colloid material. In other instances the gall-bladder is shrunken and all that remains of the organ is a diffusely infiltrated wall with a slitlike lumen in which there are biliary calculi. The two most common sites of malignant changes are (1) in the region of the fundus and (2) at the opening of the cystic duct.

Microscopic. Illingworth suggests four principal types: (1) schirrhous; (2) papillary; (3) mucoid or colloid; and (4) squamous. The reader is referred to his article for some excellent photographs and photomicrographs of carcinoma of the gall-bladder.

I. *The schirrhous carcinoma* is an infiltrative adenocarcinoma, containing irregular groups of nests and strands of columnar or cuboidal cells imbedded in a fibrous tissue stroma. In our cases sixteen, or over 50 per cent, were of this type.

II. *The papillary*, too, is an adenocarcinomatous type. However, it tends to grow in villous form, pedunculated or sessile, and is composed chiefly of columnar cells. In our series four were of this type.

III. *The mucoid or colloid* is composed of structureless areas of colloid material infiltrating the walls of the gall-bladder. The tumor cells are ill defined, flattened, and contain mucoid material. In the present study two cases were of the colloid type.

IV. *The squamous cell carcinoma* tends to form squamous-like epithelial cells which may show epithelial pearl formation and keratinization. Two such cases were observed in this series.

In two of our cases the cytologic composition was variegated. The cell structure tended to resemble an adenocarcinoma. The pleomorphic characteristics of the cells

however, did not permit grouping these cases in any one of the above subdivisions. In the remaining five cases no biopsy was taken because of the extensive metastasis to the liver and poor condition of the patient at the time of operation.

CLINICAL ASPECTS

There are no symptoms or signs pathognomonic of this disease. Since it is always associated with a chronic cholecystic condition, the symptoms will vary with the severity of the onset of the latter disease and its duration, the situation of the neoplasm and its size and the associated secondary changes. In more than half of our cases (sixteen) the history suggested gall-bladder dysfunction for more than two years and in six cases for more than ten years. (In three cases there was a history of chronic biliary disease of over twenty years.) In the latter six cases acute exacerbations began to occur from one month to one year before admission to the hospital. In the remaining fifteen cases in which no past history of acute biliary disease could be elicited, five gave a history of less than three weeks of illness, one of only four days.

Abdominal pain was the one outstanding symptom complained of by almost every patient. The pain varied from a more or less constant dull ache in the epigastric region to a severe generalized abdominal cramp followed by a persistant ache in the upper abdomen. Pain was present in twenty-six of our cases and in nineteen it was confined to the right upper quadrant of the abdomen. Associated with the abdominal pain, ten patients complained of pain in the right costovertebral region or in the right shoulder. Belching, pyrosis and distress after meals were present in twenty patients and loss of weight and loss of appetite in sixteen. Nausea and vomiting, contrary to what others have observed, were present in only fifteen (less than 50 per cent) of our patients. Jaundice, itching skin and acholic stools were observed in only eight patients; and constipation in

six. Other symptoms which were encountered in different patients were dyspnea, insomnia, chills and an intra-abdominal mass.

On physical examination of the abdomen a palpable liver with various degrees of enlargement and changes in contour of its edge was found in twenty-two cases. A mass in the region of the gall-bladder which was taken to be that organ was present in nineteen cases. In another nine, there was an indefinite mass in the right upper quadrant which was suspected of being and was later shown to be gall-bladder.

Roentgen studies have not been of help in diagnosis. In fact, such studies were often misleading in that they revealed calculi within the gall-bladder and were the basis of the erroneous diagnosis of chronic cholecystitis and cholelithiasis, and the cause of delay in institution of surgery.

The diagnosis of carcinoma of the gall-bladder should be considered as more than a remote possibility in any patient of cancer age who gives a history of gall-bladder disease, who begins to have constant annoying aches in the right upper abdomen with some loss of weight, and in whom a mass is found in the right upper quadrant. It is, however, important to institute surgical therapy in the suspected case and so modify the procedure if carcinoma is found at the time of intervention that a radical excision is performed. Cholecystectomy may not always be adequate. The surgeon should unhesitatingly remove the involved contiguous liver tissue if he is to treat carcinoma of the gall-bladder. This procedure was performed in three of the reported cases.

The foregoing more or less completely describes the findings in all cases of carcinoma of the gall-bladder. It would serve no purpose to present many illustrative cases; suffice it to present one exemplary case in detail.

N. P., a white female, aged 57 years, was admitted to the Jewish Hospital on October 6, 1937. She was always in good health until six months before admission when, without ap-

parent cause, she suddenly developed severe epigastric pain followed by nausea and vomiting. Several days after recovery cholecystography was performed and revealed calculi in the gall-bladder. The patient was put on a fat-free diet but did not improve. There were several episodes of recurrent epigastric pain which were accompanied by pain in the right infracostal and subscapular regions; these latter pains, however, were variable in severity. There was a loss of about twenty pounds in two months. At no time was there any jaundice or clay-colored stool.

Examination revealed an obese white female, not acutely ill. The head, eyes, ears, mouth, throat, glands, heart and lungs, genitourinary and nervous systems were essentially negative. The abdomen was not distended, soft, obese and tender in the right upper quadrant just below the costal margin. There was a tender mass about 2 inches below the right costal margin which appeared continuous with the liver. The liver edge was just palpable. The blood chemistry, Wassermann and icteric index were within normal limits. The hemoglobin was 74 per cent, the white blood count was 12,600 with 92 per cent polymorphonuclear cells and 8 per cent lymphocytes.

Two months prior to admission a Roentgen examination had been made of the gall-bladder region, fifteen hours after the ingestion of a suitable amount of gall-bladder dye; another film had been made twenty-four hours later and fifteen hours after taking the second dose of gall-bladder dye. This was followed by fluoroscopy in the upright and prone position during and following the ingestion of a barium meal.

On the first group of gall-bladder films: The kidney outline was sharp and clear. The liver edge was not clearly visualized. Very faint shadows suggestive of calculi were seen near the twelfth rib and close to the lumbar spine. There was no evidence of a gall-bladder shadow.

On the film made after the second dose of dye: There was still no evidence of a filled gall-bladder shadow. The calculi visible in the region of the gall-bladder were very plainly seen and formed a group of eight ring-like shadows with very thin borders. There was still no evidence of dye within the gall-bladder.

On upright fluoroscopy: The barium mixture passed rapidly and smoothly through an esoph-

agus which was normal in shape, position and motor activity. The mixture passed readily through the cardiac orifice and fell rapidly

FIG. 1. Resected tissue showing the anterior liver surface, the cut surface of the liver, the sectioned round and falciform ligaments and the neoplasm embedded in the liver substance.

along the lesser curvature to the lower pole. The stomach was J-shaped, with its greater curvature about 4 inches below the level of the iliac crest. The stomach was flexible, freely movable and not tender. There was no evidence of gross deformity in contour, nor was there any evidence of local spasticity. Very little peristalsis was established. The region of the pyloric ring was not adequately visualized and the cap was not even indicated in position.

On prone fluoroscopy: The contours of the stomach were sharp and clear. There was still no evidence of deformity. The pyloric ring was adequately visualized and, when seen well the canal was normal in width and length; filling of the duodenal cap was inadequate. At rare intervals, a small amount of barium was seen in the cap, but the outlines were never sharp or clear. The size was always much less than normal and even when best filled, it appeared flattened with faint and irregular contour.

There was no suggestion of consistent deformity characteristic of ulcer.

On October 7, 1937 the patient was subjected to surgical intervention. A right upper midrectus incision was made. The gall-bladder was distended, and there were many adhesions between the gall-bladder, the duodenum, the transverse colon and the omentum. There was a nodule the size of a small egg at the fundus of the gall-bladder and another the size of a walnut just to the right of the round ligament and within the substance of the liver. The gall-bladder contained many calculi. No other masses or infiltration could be seen or felt within the liver. The liver itself was dull and cirrhotic. The stomach and duodenum were normal and the transverse colon and hepatic flexure were normal. The common duct did not contain any palpable calculi. The pancreas was normal.

Procedure. The adhesions to the gall-bladder were separated. The cystic duct was isolated and tied, the cystic artery was similarly treated. The right hepatic and common hepatic ducts which were adherent to the nodule in the gall-bladder were dissected free from it up to the portal fissure, and the gall-bladder was dissected up further for a short distance. A pyramidal area of liver about 4 by 5 inches, with its apex at the portal fissure and including the gall-bladder with the neoplasm and metastatic deposit together with the round and falciform ligaments, was then isolated by one division of the ligaments and parietal relationship. Interrupted mattress sutures of chromic No. 2, double, in interlacing layers were passed through the outline of the pyramidal area in the liver. The entire mass was then removed with the aid of an electric cautery.

Hemostasis was perfect, with very little loss of blood. The edges of both sides of the liver were approximated with chromic gut sutures and the raw surface further covered by utilization of the remaining falciform ligament and omentum. The area was then drained as follows—a Mikulicz pack consisting of one rubber dam with four pieces of iodoform gauze was placed at the inferior surface of the liver. One cigarette drain was inserted in the lesser sac, one in Morrison's pouch and one in the subphrenic space lateral to the liver. The wound was closed in layers with chromic catgut throughout—continuous for the peritoneum,

interrupted for the anterior sheath and muscle, and retention black silk sutures for the skin.

The postoperative course for the first twelve

gray rim surrounding a central area of firm yellow arborizations, through which pink strands ramify. Encapsulating each nodule is
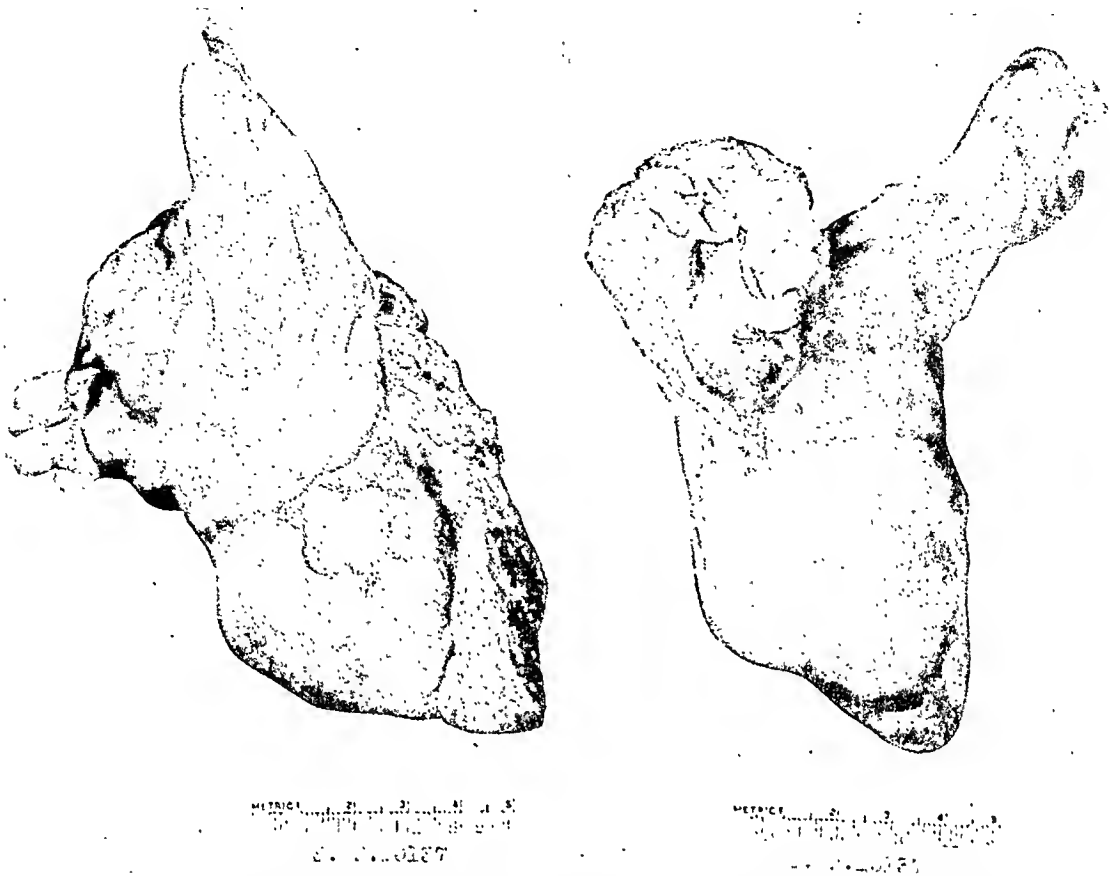
Fig. 2. Same as Figure 1. Seen from the inferior surface, showing the primary neoplasm, the secondary deposit in the liver, the cut surface of the liver and the gall-bladder.

hours was stormy, but after that the patient continued to improve slowly. The patient was discharged with a draining sinus on the thirty-first postoperative day. During the last two weeks of her stay at the hospital there was a low grade temperature (98.6 to 100 degrees).*

A pathologic report (Dr. Lederer) of the tissue removed was as follows: "The specimen consists of a stony, hard mass 12 × 6 × 14 cm., to which is attached the gall-bladder. (Fig. 1.) Part of the external surface is smooth, discolored bluish-red, the remainder is covered with soft brown tissue. On section the mass is further subdivided into two fairly well circumscribed irregular nodules, 5 cm. in diameter and 3.5 cm. in diameter and connected by a bridge of soft tissue similar to that covering the external surface. (Fig. 2.) The cut surfaces of the nodules are composed of a firm outer pearly-

an irregular portion of soft, light brown tissue streaked with red. One end of the larger mass is directly continuous with the wall of the fundus of the gall-bladder. The outer wall of the smaller nodule is closely adherent to the outer wall of the gall-bladder at its fundus. The external surface of the gall-bladder is rough and discolored. The lumen contains ten soft, faceted, combined dark green and yellow gallstones. (Fig. 3.) The mucosa is light green and its pattern is indistinct. The wall of the gallbladder varies in thickness up to 0.5 cm. At the fundus it is closely adherent to the larger nodule and infiltrated with the yellowish tissue seen in the center of the mass. Sections were taken through the gall-bladder and nodules.

"Microscopic. In a preparation from the wall of the gall-bladder adjacent to the tumor mass, the mucosal surface at one end is thrown into coarse and delicate folds covered by tall columnar cells. Here occasional outpouchings of the mucosa are seen in the greatly hypertrophied muscular coat. The connective tissue

*The patient was last seen on December 15, 1938. She was apparently in excellent physical condition, there was no evidence of recurrence, and she had regained 26½ pounds to her normal weight.

of the tunica propria is markedly increased in amount and is infiltrated with small and large mononuclear leucocytes. The intermuscular

FIG. 3. The gall-bladder opened, showing a solid tumor at the fundus and calculi in the lumen.

to merge with the tumor cells. The latter are large, cylindrical cells, varying in size, shape and chromatic nuclear content—some are giant-sized and occasionally contain two nuclei. They grow in nests, strands and cords, and in some places assume an acinar structure. (Fig. 4.) The stroma is abundant, dense, hyalinized and infiltrated with mononuclear cells, plasma cells, and polymorphonuclear cells. In some areas there are also seen endothelial lined spaces. Extensive areas of necrosis are also present in some regions. Other preparations from the tumor mass show similar changes. The tumor here too, grows in nests, strands and cords and is embedded in abundant hyalinized tissue which is infiltrated as described above. In some of the preparations the areas of necrosis are more extensive than in others.

"The preparation taken from the gall-bladder, remote from the tumor, shows the mucosal surface thrown into folds covered by cylindrical cells. Invaginations of the mucosa are seen extending to the somewhat hypertrophied muscular coat. The connective tissue of the tunica propria, as well as the intermuscular and perimuscular connective tissue,
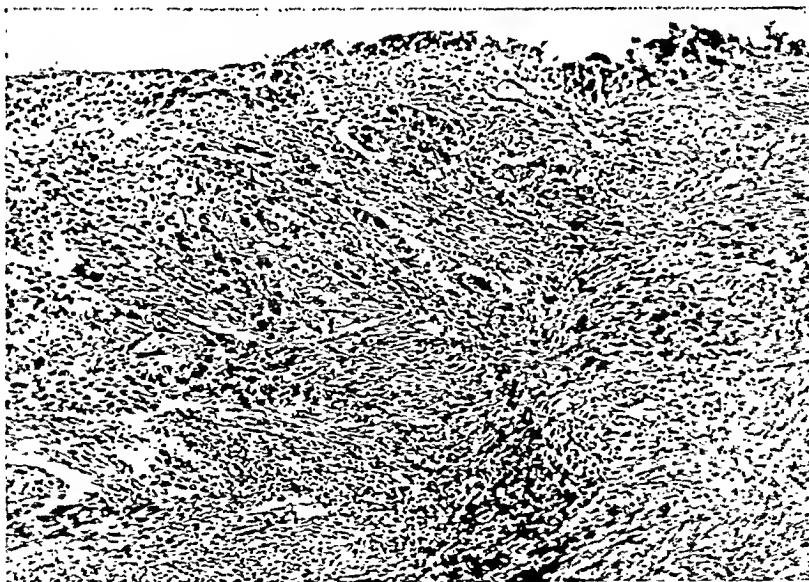
FIG. 4. Photomicrograph of the tumor tissue, showing strands and nests of carcinoma cells embedded in a hyalinized tissue stroma. (× 200.)

and perimuscular connective tissue are likewise increased in amount and similarly infiltrated. In places the cellular infiltration is quite dense. Near the tumor cells lining the mucosa there are some cells somewhat larger and with deeper staining nuclei. In places the lining cells seem

is increased in amount and infiltrated with mononuclear cells, eosinophiles and polymorphonuclear leucocytes.

"In the preparation taken from the liver, the usual cytologic architecture is still well maintained. The sinusoids and veins are dis-

tended. The cells appear large with vesicular nuclei and granular, somewhat vacuolated cytoplasm. In the periportal spaces there is an infiltration of mononuclear cells and polymorphonuclear leucocytes. There is an increase of fibrous tissue and a diffuse cellular infiltration in some places. Tumor tissue is present near the margins of the preparation."

SUMMARY

A case is reported of carcinoma of the gall-bladder with complete removal of the gall-bladder and contiguous extensions to the liver. Thirty-one other cases of carcinoma of the gall-bladder are reviewed with a brief résumé of the recent literature and clinical manifestations of the disease.

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RESECTION OF THE MANDIBLE FOR MEDULLARY OSTEOSARCOMA*

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INTRODUCTION

OSTEOLYTIC medullary lesions of the mandible present difficult problems in early and differential diagnosis. The clinical history and physical examination of the patient may contribute only partly towards a diagnosis. Stereoscopic roentgenograms of the mandible, while identifying the relation of the lesion to the bone and the demonstration of its radiolucency, still may not clarify the distinction between bone cysts, the localized form of osteitis fibrosa cystica, radiculodental cyst, and osteolytic central or medullary osteosarcoma. A third important measure in the establishment of a correct diagnosis is early and conclusive biopsy examination; this test requires experience in the selection of proper tissue for the examination, and even more experience by the pathologist in the identification of the tissue from the biopsy specimen.

The three common types of mandibular sarcoma are periosteal fibrosarcoma, the periosteal osteogenic sarcoma and the medullary osteogenic sarcoma. The periosteal fibrosarcoma is a tumor arising from the fibrous layers of the periosteum. Because of the absence of osteoblasts, there is no tendency to the production of bone. These tumors, in contrast to the osteogenic group, have little tendency to involve bone, but cause pressure erosion or absorption of contiguous bone. The periosteal osteogenic sarcoma of the mandible also causes an early swelling to appear on the external or internal surface of the mandible, but it also destroys the cortex of the bone. The medullary osteogenic sarcoma, on the other hand, is seldom detected early, because of its central location. This sarcoma is the most frequent type occurring in the mandible. An example of the medullary osteosarcoma and the principles of treatment of this tumor may be illustrated in the following report of a case.

T. M. C., a man aged 30 years, experienced discomfort in the left lower jaw for the first time in July, 1936. On September 23, 1936, following an x-ray study of the mandible, the lower left second and third molar teeth were extracted, and an attempt was made to enucleate a suspected cyst involving these two teeth. No identifiable tumor tissue was seen at the time of this exploration, nor during the following three months, while the patient was under observation. On January 11, 1937, roentgenograms were again taken of the lower left mandible. A formal incision was made into the visible cystic cavity, but no tumor was encountered at the time of curettage.

Physical Examination. On February 20, 1937, an intraoral examination revealed a soft, localized mass involving the left sublingual region and fusing into the lingual plate of the mandible. This mass extended over a region from the lingual surface of the first molar tooth distally to the retro third molar space and from the gingival border of the lingual surface of the mandible deeply into the soft tissues of the floor of the mouth. Palpation of this mass elicited tenderness on pressure, but not actual pain. The lower left second and third molar teeth were absent, with a completely healed surface over the crest of the mandibular ridge. No signs were demonstrable extraorally except some slight inflammation in the left submaxillary gland.

Roentgenologic Study. An x-ray examination showed a spherical, well demarcated radiolucent cavity, about 2.5 cm. in diameter.

FIG. 1. X-ray taken September 16, 1936 which preceded the extraction of teeth. Radiolucent area is shown involving the second and third molar teeth.

This extended from the distal border of the first molar tooth to the angle of the mandible and from the crest of the alveolus to the lower border of the mandible, so that only the cortical plate of the bone remained intact.

FIG. 2. Roentgenogram of mandible revealing the location of the osteolytic tumor.

Diagnosis and Treatment. An aspiration biopsy made at this time obtained tissue which was not diagnosed as tumor. Because of the history of profuse bleeding following the previous incision and curettage of the lesion, together with its progressiveness, the presumptive diagnosis was made at this time of an hemangioma of the bone, or a telangiectatic variant of osteitis fibrosa cystica.

Fractionated doses of high voltage x-rays were given to one external field directed toward the tumor. The factors of treatment were
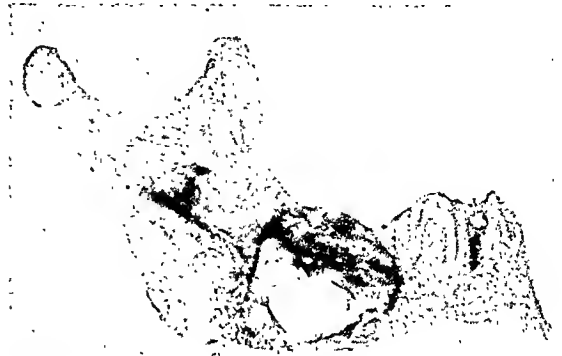
FIG. 3. Resected mandible showing the tumor in position.

Kv. 200, filter $\frac{1}{2}$ mm. of copper and 1 mm. of aluminum, target-skin distance 62 cm., size of field, 5 cm. cone, dose 200 r daily, administered on consecutive days until a total dose of 3,600 r were administered.

The Roentgen therapy was completed by April 1, 1937, and before that time the external swelling of the mandible had entirely disappeared. There was some residual tumefaction on the inner aspect of the horizontal ramus posteriorly, but this had disappeared by May 1, 1937. Stereoscopic roentgenograms of the mandible made on May 22, showed that osteogenesis was proceeding satisfactorily; the bony defect was closing and there was increased density of the surrounding normal bone.

The patient did not return for his next specified appointment in June 1937, and it was not until October 23, five months following his last examination, that he presented himself for further observation. Roentgenograms taken at this time revealed a more extensive radiolucent area in the medullary cavity of the mandible, with progressive erosion of the surrounding bone. Physical examination showed an increased swelling of the tissues over the medial aspect of the horizontal ramus of the mandible, and extending deeply toward the lingual margin. The patient had experienced discomfort during mastication, and some pain referred to the left temporomandibular articulation.

An aspiration biopsy was taken on October 28, 1937. It was diagnosed by Dr. Fred Stewart

as a malignant spindle-cell sarcoma, presumably medullary osteogenic sarcoma of the mandible.

FIG. 4. Photomicrograph of medullary osteogenic sarcoma.

On November 5, 1937, interdental wires were placed in position on the teeth of the right mandible and maxilla preparatory to resection of the left mandible and subsequent approximation of upper and lower jaw. The

FIG. 5. Prosthesis with joint arrangement to hold upper and lower jaws in alignment.

operation for resection of the left mandible was performed on November 6 under avertin anesthesia, supplemented with endotracheal ether. The operation was preceded by ligation of the external carotid artery for the control of hemorrhage. It was carried out entirely within the mouth. The mucoperiosteal flaps were made along the crest of the gingiva, beginning at the lateral incisor tooth and

extending distally up the anterior border of the ramus. The lower left two bicuspid and first molar teeth were extracted. The mandible was partly exposed from the periosteum both lingually and buccally by blunt dissection. A Gigli saw was then passed lingually along the distal border of the lower left cuspid tooth and, by an extraoral puncture of the skin, was

FIG. 6. Prosthetic appliance in position.

carried through to the outside. The mandible was then severed by the saw along the distal margin of this tooth. The masseter and internal pterygoid muscles were detached by sharp dissection. The more deeply situated temporal and external pterygoid muscles were then detached at their insertion, thus exposing the tumor mass. The capsule of the temporomandibular joint was now incised, and the condyle separated from its fossa. The mucous

membrane was partly coapted and sutured. Iodoform gauze was placed into the deeper portions of the wound, with a second section of plain gauze over this first packing. Very little postoperative bleeding was encountered.

Twenty-four hours after the operation the interdental wires were connected by intermaxillary wires and in this way the remaining portion of the mandible was held in a stabilized occlusion. The first gauze packing was removed within forty-eight hours following the operation. Oral cleanliness was maintained by daily irrigations with saline solution, alternated with potassium permanganate 1:5000 solution. The diet consisted of high caloric liquids, administered through a nasal feeding tube for the first twenty-four hours, and then by an oral feeding for the first two weeks.

Pathologic Report. The specimen consisted of the lower left mandible, apparently separated at the mental symphysis. The inner portion of the middle third of the horizontal ramus was occupied by a tumor which had eroded and replaced the outer table of the bone over an area measuring 1.5 cm. in diameter. The tumor tissue was white and soft. On sectioning, the tumor tissue was found to involve the medullary portion of the bone. It was well demarcated and surrounded by a thin capsule.

Microscopic study by Dr. A. H. Davis revealed spindle-shaped tumor cells in a palisade arrangement. An occasional mitotic figure was found. In some foci the tumor cells were very closely packed together, whereas in other locations they were widely separated by hyalinized fibrous tissue. Sections prepared from the margin of the tumor showed a thin capsule composed of dense fibrous tissue which was infiltrated in many regions by the tumor cells. There was no evidence of bone formation in any sections made from the tumor proper.

Subsequent Course. The upper third left molar tooth was extracted, because it irritated the cheek. All wires were removed from the teeth by January 4, 1938. Two months following the operation, a prosthetic appliance was placed in position for retaining the remain-

ing portion of the mandible in a functional position during the opening and closing of the jaws. This hinged clasp connecting an upper

Fig. 7. Anterior view revealing little deformity. No appliance in mouth.

and lower plate attached to the teeth is shown in Figures 5 and 6. The patient was last observed on September 20, 1938, at which time there was no evidence of recurrence. No external scarring could be seen, and the functional and cosmetic results were satisfactory, not only to the physician, but to the patient as well.

SUMMARY

A case report is given of a medullary osteogenic sarcoma of the mandible, treated by hemiresection of the mandible. This destructive operation may be performed without mutilation or functional impairment.

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CONSERVATIVE MANAGEMENT OF DAMAGED RENAL TISSUE*

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WHAT we term here as conservative treatment is not meant to apply universally. We mean it as applying only to the cases here reported. We realize that conservatism in one man's hands is perhaps not conversatism in the hands of another.

We wish to call attention to, and emphasize, the fact that our procedures in these cases were governed by more than one factor. In some instances the financial status of the patient influenced the procedure; in other cases the general health and presence of complications, while in some of them the procedure was influenced by the will of the patient.

CASE REPORTS

CASE i. Mrs. B. was first seen in the Baptist Hospital in June 1928, bed-ridden, pale and emaciated, complaining of frequency and dysuria. Five years previously the right kidney had been removed. The preoperative and postoperative diagnosis was tuberculosis. Acid fast bacilli were found in the urine from the remaining left kidney and the bladder. Guinea-pig inoculation was positive.

This was our first case of tuberculosis found in a solitary kidney. Previously we had removed the tubercular kidney when a good kidney was found on the opposite side. There was no evidence past or present of tuberculosis of the lungs.

Since there was no hope in surgery, we decided to treat the patient as a case of pulmonary tuberculosis, and therefore sent her home. She rented an ultraviolet lamp. She was exposed daily to the rays of this lamp at a distance of 30 inches over the entire body. The exposure began with one minute, and increased one minute per day up to twenty minutes. During this time she was on forced feedings, and had complete rest in bed.

After six months of this régime she was able to be up part of the time, and made a visit to the office. Within nine months, she was doing part of her house work. After eighteen months had expired she considered herself normal. For the past six years indirect reports indicate that she is enjoying perfect health.

CASE ii. L. K., a white female, age 28, entered St. Thomas Hospital complaining of frequent attacks of pain beginning in the left shoulder and radiating to the left kidney region. Attacks usually lasted about a week.

Physical examination was negative except for tenderness to deep pressure over the left kidney region. Upon cystoscopy, a No. 6 catheter passed to the right kidney pelvis, but met obstruction on the left about 2 cm. from the left ureteral orifice. Right pyelogram was normal and cultures negative. A left pyelogram was suggestive of tuberculosis, because of the moth-eaten appearance of the lower calyces. A guinea-pig test was positive on the left for acid fast bacilli.

The patient was unable to rent or buy an artificial sunlight lamp, and she was therefore advised to lie in the sunshine naked. She had a special arrangement built in the back yard of her home, went home every day from her office and exposed her entire body to sunlight beginning with one minute and increasing to twenty minutes per day. It was fortunate that during August and most of September that year the sun continued to bless that portion of Tennessee. She soon felt better. During her sunbath treatment she was on forced feedings and stayed in bed every minute she was not working in the office. She gained 19 pounds in two months.

Correspondence about every six months has revealed that she is well and happy.

Some time ago I wrote her and asked her to come in for a check-up (without cost to her). She replied, "I never felt better in my life. I

FIG. 1. Case III. Pyelogram of the right kidney showing wide dilatation of the right kidney pelvis. Note the enormous stretching of the minor calyces.

FIG. 2. Three months later, showing return of minor calyces to normal but still some enlargement of the kidney pelvis.

have been out of the office only two days in the past five years, and will see you some time if business calls me to Nashville."

CASE III. J. M. C., white male, age 29, a policeman, entered hospital October 31, 1935, with a typical attack of renal colic on the right side, of one week's duration. He had been treated by his local doctor during this period with opiates. The pain originated in the right kidney region, radiated medially and downward to the bladder, to the right testicle and thigh. He had frequency, urgency and hematuria. His past history was negative except for a fracture of the lumbar spine in 1932.

Catheters passed easily to both kidneys. Urine escaped in a stream from the right kidney, which, when decompressed, could not be palpated. This relieved the patient of pain. X-ray revealed a large hydronephrosis on the right. Two days later the patient went home, and in forty-eight hours he returned with symptoms of obstruction in the right ureter, a temperature of 104, pulse 130, respirations 20. Pyelogram revealed a massive hydronephrosis with wide dilatations of the minor calyces. Nephrectomy was considered. (Fig. 1.) Drainage of right kidney again relieved him and his temperature dropped to normal in a few days.

He had frequent cystoscopies over a period of two months, during which time he passed

three stones, two of which were alike, the third darker in color. A recent pyelogram reveals the right kidney pelvis has returned almost to normal, especially the minor calyces. (Fig. 2.)

This case is presented not so much as an

FIG. 3. Case IV. Pyelogram showing what appears to be a dead kidney. This kidney regained 40 per cent function without any change in the picture as shown by pyelogram.

example of conservatism, but as an example of how the kidney can restore itself.

CASE IV. E. M. K., age 56, unmarried female, very obese, was seen on May 27, 1936.

She complained of attacks of pain in the right kidney and suprapubic region, accompanied by chills, fever, frequency and dysuria.

FIG. 4. Case v. Pyelogram taken in the erect position before nephropexy.

FIG. 5. Pyelogram, erect position three months after operation.

Cystoscopy revealed nothing but pure pus from the right kidney, which was under high pressure. The amount of pus drained from the right kidney pelvis at the first cystoscopy was 50 c.c.; no urine was obtained. The right kidney

FIG. 6.

FIG. 7.

FIGS. 6 and 7. Stone obstructing lower left ureter.

pelvis was lavaged once weekly for five weeks. The amount of pus decreased and the amount of urine increased.

The patient is now able to go for one month or more without lavage, and the last three

cystoscopies have revealed only a small amount of pus in the urine.

It is noticeable in this case that though the symptoms have cleared up and function has been restored, the pyelogram did not change in character. (Fig. 3.) Nephrectomy was advised but the patient refused operation. Now by conservative methods we are able to keep her on her job as a clerk.

CASE v.   Mrs. P. V., age 32, married with three children, entered the Nashville General Hospital January 6, 1937, complaining of a

movable mass in the right side. She had had intermittent severe colic on that side which she could relieve by standing on her head. She had frequency and urgency with these attacks but no chills. These attacks of colic occurred once or twice each month for two years. Her past history was essentially negative except for removal of a cervical polyp May 27, 1936.

Physical examination revealed a thin pale woman of 32. Heart and lungs were negative. The right kidney was felt slightly enlarged and tender just above the superior spine of the ilium. It was fairly movable.

The white blood cells numbered 9,000. Urinalysis and urine cultures were negative. N.P.N. was 35; P.S.P. of the right kidney was 1 per cent and of the left kidney 14 per cent in ten minutes.

At cystoscopy the bladder appeared normal and catheters passed easily to the pelves of both kidneys. Specimens from the two sides were normal. Pyelogram on the right side showed nephroptosis, hydronephrosis, and kink. (Fig. 4.) A nephropexy was done January 18, 1937, and a pyelogram three months later showed the kidney in normal position (Fig. 5), the hydronephrosis relieved, and normal function on that side.

The patient has been well and free of symptoms since she left the hospital February 8, 1937. This patient was not benefited by a belt, because the kidney was too low to insert a pad below it.

Case vi. L. D., white male, seven years ago presented himself with a complaint of left sided renal colic. X-rays showed a stone in the left ureter. (Fig. 6.) He would not agree to surgery, but went off to Kentucky to buy medicine from a quack which was guaranteed to dissolve stones. About three months ago he returned. X-rays showed that the stone had moved downward to within 2 inches of the ureteral orifice. (Fig. 7.) By this time he had lost a great deal of weight, was suffering with general malaise, loss of appetite and frequent attacks of chills and fever.

The stone was removed through an abdominal incision. When the ureteral wall was opened and the stone plug removed, at least three pints of liquid heavily loaded with pus escaped under moderate pressure. Two months after operation a pyelogram was made. The capacity of the left kidney was 50 c.c. (Fig. 8) and P.S.P. excretion was 5 per cent in ten minutes.

Two months after operation he was seized with violent renal colic on the right side, and for four days was very ill with acute pyelitis.

Fig. 8. Case vi. Pyelogram of the left kidney which had no function following operation, but which had regained a P.S.P. return of 5 per cent in ten minutes three months after operative removal of calculus shown in Figure 7.

We feel that his right kidney might not alone have been sufficient to furnish the necessary kidney function.

This case demonstrates how much punishment a kidney can sometimes take, and yet regain an amazing per cent of normal function.

Case vii. On April 19, 1929, H. W., a colored man of 25, presented himself at the Vanderbilt hospital complaining of pain in the sides and back and hematuria. He stated that he had been passing blood from his bladder for two years intermittently, and that occasionally clots would obstruct the urethra.

He was studied with a view to determining the etiology of the bleeding. His blood picture and blood calcium were normal. Guinea-pigs inoculated with specimens of the urine failed to die of tuberculosis. At frequent cystoscopies bleeding was observed to come from both ureteral orifices or more often one orifice at a given observation. Repeated pyelographic studies failed to reveal evidence of any abnormality along the ureter or in the region of the kidneys that would account for the hematuria. Kidney function tests taken in intervals when there was no bleeding revealed the kidney function to be normal on the two sides.

This patient was followed for a period of four years during which time there were periods of profuse bleeding, light bleeding and no bleed-

Fig. 9. Catheter from pyelotomy opening draining into a rubber bag. For two and one-half years this patient has been able to work, collecting his urine in this manner. He has only the left kidney (congenital) and passes no urine from the bladder.

ing. On more than one occasion transfusions were resorted to as a life saving measure. The right kidney alone produced the hemorrhage six times, the left alone one time and on several occasions both kidneys bled simultaneously.

When first seen this patient was bleeding from the left kidney alone and nephrectomy was delayed only because no reason could be found for the bleeding. We feel that if nephrectomy had been done we surely would have lost the patient during his attacks of bleeding from the right kidney. We cite this case as a caution against nephrectomy in hemorrhage of undetermined origin.

CASE VIII. H. L. M., male, age 35, was seen in August 15, 1934 in consultation with Drs. Teachout and Magruder of Nashville, by whose permission it is now reported.

The chief complaint was painful swelling in the left abdomen. For the past year there had been intermittent swelling in the left side of the abdomen, accompanied by pain. Attacks occurred at intervals of a few weeks and lasted as long as a week. The swelling involved the entire left half of the abdomen at times, but

was most pronounced just below the costal margin. It was tender, firm and slightly movable. Attacks were accompanied by frequency

Fig. 10. Case VIII. Pyelogram of congenital solitary kidney. Note the marked hydronephrosis and hydroureter. There is evidence on other plates that this ureter passes upward and medially to enter the bladder, thus passing behind the vena cava.

and hematuria, consisting of bright red blood clots. Between attacks the patient felt weak, "fagged out" and extremely nervous. The swelling did not entirely disappear, but a mass about the size of a hen's egg could be felt all the time. Five cystoscopies and one intravenous urogram had all failed to show the presence of a right kidney.

The patient had suffered during childhood with incontinence of urine. In 1921 he was thrown by a mule and had hematuria for three days. In 1927 he had an attack of acute pain in the left kidney region. Physical findings showed a large, exquisitely tender, slightly movable mass, filling the entire left side of abdomen.

Intramuscular injection of phenolsuphonephthalein was followed by return of 1 per cent in the first hour, 1 per cent in the second and 2 per cent in the third, a total of 4 per cent in three hours, with 725 c.c. of urine. N.P.N. was 67 mg. per 100 c.c. The white blood count was 6,600.

A second P.S.P. one week later showed: first hour 5 per cent; second hour 10 per cent; third hour 5 per cent, a total 20 per cent in three hours, with 550 c.c. of urine. The N.P.N. was 60 mg. per 100 c.c.

The cystoscope entered easily. The prostate was markedly enlarged from infection and edema. A No. 6 catheter seemed to pass all the way to the left kidney pelvis. Nothing would enter the only thing which seemed to be the right ureteral orifice. Fluid dripped rapidly from the left catheter, until 300 c.c. had been drawn off, then the flow decreased. Cultures were negative for ordinary pyogenic organisms. Attempts were made to do a pyelogram and a pyelo-ureterogram on the right, but the catheter was blocked.

The temperature had been ranging from 98.6 to 99.4. Next day, after cystoscopy, it was 104.2. The patient was desperately ill and the kidney could not be drained with a catheter. Surgery was imperative.

A lumbar incision was made down to the kidney, and the kidney stabbed. Fluid shot about 3 feet high and ran all over the patient and operating room floor. It was estimated that there was a gallon or more. The kidney wall was about $\frac{1}{16}$ inch in thickness. A Pezzer catheter was placed in the kidney. The temperature dropped to normal in four hours and then ranged from normal to 103 for four days, after which it remained normal.

The patient left the hospital on the twelfth postoperative day, wearing the Pezzer catheter with a hot water bottle to receive drainage from it. He soon changed to a straight catheter instead of the Pezzer. He and his wife have given the necessary care.

For two and one-half years he has been in perfect health and has bought, paid for and managed a grocery store. (Figs. 9 and 10.) He passes no urine from his bladder, depending entirely on the catheter he wears in the pyelotomy opening.

SUMMARY

We thought it might be of interest to present some cases which, due to factors beyond our control, made conservatism a necessity. Also, some cases in which conservatism is the method of election. We wish it understood that we do not advocate palliative treatment in renal tuberculosis except in cases where it is a necessity.

One cannot overemphasize the "comeback" ability of renal tissue following removal of the causative factors of damage. This is especially true in mechanical obstruction of the ureters as seen in ureteral calculi. An analysis of the kidney response in cases as cited above is often of great help in making a vital surgical decision. Damaged renal tissue can often be nursed back to health but when removed is forever lost.

SPONTANEOUS PERIRENAL HEMATOMA (SUBCAPSULAR)

CASE REPORT

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PERIRENAL hematoma is a disease of very rare occurrence, few cases having been reported in literature. There are on record sixty-four cases of subcapsular perirenal hematoma since Raye, in 1839, first described this condition. Wunderlich, in 1846, gave a rather comprehensive account of this condition and termed it renal apoplexy.

Several authors do not recognize perirenal hematoma as a distinct entity, but believe that it is always associated with alterations of the kidney or its capsule.

Greco[1] classifies perirenal hematomas as (1) subcapsular; (2) extracapsular; and (3) mixed. The kidney itself may be perfectly normal or it may show ischemic areas due to pressure, congestive lesions of varying degrees, or small cortical or subcapsular hemorrhages. Coenen[2] speaks of subcapsular or perinephritic hemorrhages, comparing them with the disease hemorrhagic pachymeningitis, the etiology of which is also obscure.

Etiologically these cases fall within the following groups:

1. Disease of the renal parenchyma and smaller blood vessels, neoplasms, tuberculosis, pyelonephritis, polycystic disease, typical anemic infarcts, arteriosclerosis of the perirenal vessels, and possibly periarteritis nodosa, as in the case of Weaver and Perry.[3]

2. Extrarenal retroperitoneal causes, namely: aneurysms of abdominal aorta, renal or spermatic arteries or hemorrhages from the adrenal vessels.

3. Hematomas associated with blood dyscrasias, such as hemophilia, thrombopenic purpura, and polycythemia.

Clinically, one must distinguish between acute and chronic forms.[4] The acute form is characterized by sudden pain of great severity usually generalized over the entire abdomen, most exquisite in the lumbar region. The picture is that of an acute surgical abdomen plus signs of internal hemorrhage. Later the pain may radiate downwards or upwards, simulating renal or ureteral calculus. Internal hemorrhage manifests itself by the usual signs of pallor, rapid thready pulse, thirst, restlessness, air hunger and dyspnea. The blood picture shows a marked reduction of hemoglobin and red blood cells. A tumor mass usually forms over the kidney region in four to twelve hours—this is one of the cardinal findings in cases of perirenal hematoma. The mass is often visible on inspection and practically always palpable, usually down to the crest of the ilium. The mass is smooth, regular, elastic, and sometimes fluctuant. Peritonitic symptoms of vomiting, rigidity and obstipation follow only the vastest extravasations. In general, the urine is of little value for diagnostic purposes. The majority of cases show albuminuria, probably due to pressure of the hematoma on the kidney substance. Hematuria is rarely present in the subcapsular type of perirenal hematoma.

In the chronic form the onset is more insidious, the hematoma forming slowly in two days to several weeks. Unlike the acute form, the pain is colicky in nature and not so severe. The patient usually feels a sense of weight or fulness in the affected lumbar region, which may be the only symptom present. Symptoms of acute internal hemorrhage and shock are much modified or absent in the chronic form. In some cases of a chronic nature, the onset often remains unobserved. The lesion may be tolerated for an entire lifetime and be observed only

as a surprise finding at the operating table or at autopsy.[5]

Correct preoperative diagnosis is often

Expectant treatment is almost invariably fatal, surgical procedures offering the best chance for recovery. Evacuation of

Fig. 1. Showing outline of huge left kidney.

difficult. Temperature may be elevated following reabsorption of part of the extravasated blood or secondary infection. The most frequent tentative diagnoses are intestinal obstruction, perirenal abscess, or kidney tumors. Lenk[6] described a classical triad of abdominal pain, progressive pallor (due to internal hemorrhage), and the presence of a tumor mass in the kidney region as diagnostic of perirenal hematoma.

Prognosis in the acute form is very poor, with or without surgery. According to Greco the mortality of operated cases is over 50 per cent. In the majority of acute cases death is due to hemorrhage or secondary renal infection. Prognosis in chronic forms is less grave, about 22 per cent.

the clot with tamponage, and drainage has a mortality of 40 per cent, while nephrectomy carries a mortality rate of 22 per cent.

The authors recently had occasion to observe and operate on a large perirenal hematoma of two months' standing.

A white female of Russian descent, age 46, 5 feet 6 inches tall, weighing 140 pounds, had enjoyed good health prior to 1933, when she had a hysterectomy and an appendectomy with apparent complete recovery. She gave a history of having had the usual childhood diseases. Venereal disease was denied. She was a para 3, and had had no stillbirths, miscarriages, or abortions. The children were all living and well.

The present illness began in November 1936. While attending her housework she experienced

a severe knifelike pain in the left lower abdominal quadrant, which became generalized. She immediately took soda, but obtained no relief.

touch and she felt nauseated when the mass was palpated. She at no time complained of hematuria, dysuria, polyuria or frequency of
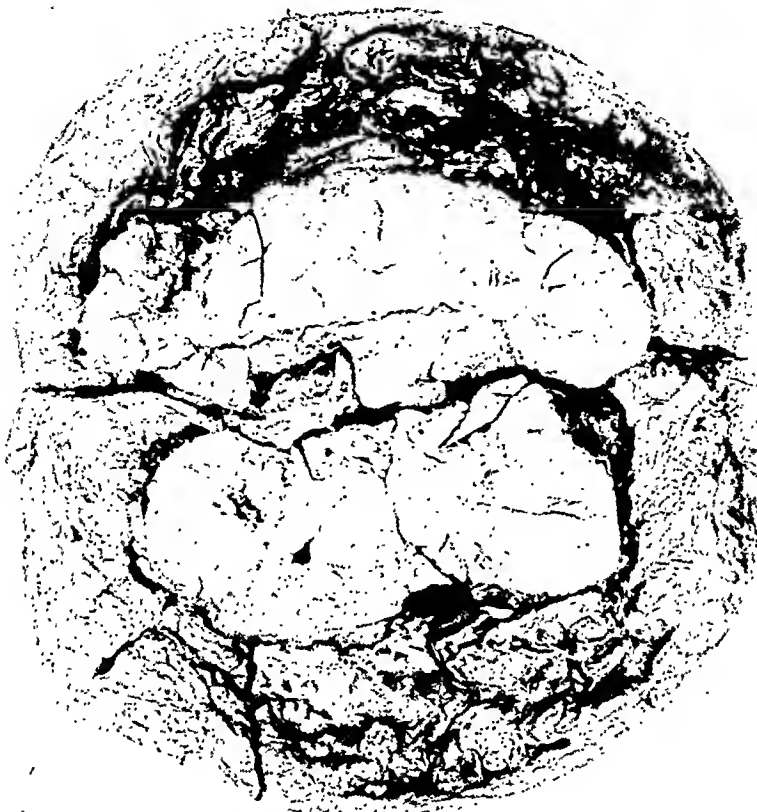
FIG. 2. Showing specimen of left kidney and hematoma.

She was forced to lie down for six hours because of her pain. As she lay on her left side, the pain radiated to the right lower quadrant and epigastrium. She became nauseated, vomited twice, and had a slight chill which lasted about five minutes.

Pain and nausea lasted several hours, and then the acute pain subsided. On arising several hours later, she experienced a feeling of heaviness in the left kidney region. When questioned closely, the patient stated she felt no mass, but experienced a marked tenderness over the left lumbar region on light pressure. From that time until she was hospitalized she had attacks of colicky pain in the left renal region every six or seven days. Pains were present only on physical exertion. She had no nausea or vomiting after the initial attack. About two months after the attack, while dressing, she felt a mass in the left lower quadrant just above the crest of the ilium. She stated that it was sore to the

urination. There was no history of trauma at any time.

We saw this patient for the first time on January 17, 1937, palpated the mass and hospitalized the patient the same day. A more detailed history showed that the patient had lost her appetite since the initial attack. She complained that "food would not go down." She had an emesis following each meal for two weeks previous to hospitalization. She lost 15 pounds in weight, probably due to the fact that she was unable to retain food.

Physical examination revealed a well nourished, white adult female, who appeared not acutely ill. She entered the hospital with a temperature of 101 degrees rectally, blood pressure of 140/80, pulse of 100 and respirations of 22. Head and scalp were negative. The pupils reacted to light and accommodation. The sclera was normal, no jaundice. The ears were essentially normal with no discharge and normal

hearing. In the mouth there was an upper plate, with the lower teeth in good condition. Tonsils were present and normal. The tongue was coated. There was no cervical adenopathy, no visible pulsations of the neck, no enlargement of the thyroid. The chest revealed normal and equal expansion. The breasts were soft with no tumors palpable. Fremitus, resonance and breath sounds were normal and there were no râles present. The heart was within normal borders, its rhythm regular, and no murmurs audible.

Inspection of the abdomen revealed a slight elevation of the left lower quadrant which when palpated revealed a mass the size of a large grapefruit, extending from the costal margin on the left side down to the crest of the ilium. It was round, hard, smooth, very tender, immobile and not fluctuant. Liver and spleen were not palpable. There was no ascites but a marked tympanites was present.

Extremities revealed no evidence of a loss of subcutaneous fat. There were no varicosities, no ulcerations or scars. Vaginal examination was negative, and no tears were present. The uterine fundus was absent. No rectocele or cystocele was present. Rectal examination showed no fissure, hemorrhoids or fistulas.

The specific gravity of the urine was 1.020. No sugar was present, but there was 3 plus albumin. Microscopic examination revealed 100 white blood cells per high power field, a few epithelial cells, and 10 to 20 red blood cells.

Blood analysis revealed a hemoglobin of 70 per cent; R.B.C. 3,700,000; and W.B.C. 11,650. There were 10 per cent small lymphocytes, 13 per cent large lymphocytes, 74 per cent polys, 2 per cent eosinophiles and 1 per cent transitionals. The coagulation time was four minutes.

Cystoscopic examination disclosed inflammation of the trigone and vesical neck. The right ureter appeared normal, the left ureter inflamed. Phenophthalein appeared from both sides within four minutes. A total of 45 per cent of the dye was eliminated in fifteen minutes. The kidney pelvis of both kidneys was essentially negative. Specimen of urine from the left kidney showed many red blood cells and leucocytes. The urine from the right kidney was negative.

In attempting to establish a diagnosis, a barium enema was given and a flat plate taken. (Fig. 1.) The roentgenogram showed a mass

posterior and mesial to the descending colon, which was apparently a huge left kidney, reaching to the crest of the ilium and extending well into the flank. There were no shadows suggestive of calculi. The outline of the left kidney was smooth and regular, and the right kidney was larger than usual. The large bowel showed no masses or constrictions, the barium passing freely through the entire colon.

It was therefore concluded that this patient was suffering from a large mass in the left retroperitoneal space, a hypernephroma of the kidney being the first consideration. A second diagnosis was retroperitoneal tumor, in all probability a malignancy.

An exploratory operation was performed on January 21, 1937, under spinal anesthesia, 200 mg. of novocaine being used. Because of the huge size of the tumor a transperitoneal T-shaped incision was made over the outer border of the left rectus muscle. The posterior peritoneum was separated from the kidney capsule by blunt dissection and packed away from the operative field. Further exploration revealed a smooth, firm, symmetrical tumor, the size of a large grapefruit, and immovable. It was bound down by what appeared to be freshly formed adhesions which were easily destroyed with the finger, and the mass was delivered out of the renal bed. No aneurysms were found in the renal pedicle. Because of the shortness of the pedicle no attempt was made to place ligatures around it. The pedicle was doubly clamped, cut above the clamps and the mass removed. The clamps were allowed to remain on the kidney pedicle, being gradually released each day, until the fourth day when they were removed. The abdomen was closed in the usual manner with a small drain placed in the kidney bed.

The specimen weighed 956 gm. and measured 19 × 12 × 9.5 cm. It consisted of a kidney with perirenal fat and adrenal gland. The medulla of the adrenal gland was soft. Incision of the kidney showed a large hematoma 7 cm. in diameter beneath the capsule. There was some liquefaction and partial organization. The blood infiltrated the fat. The renal cortex was 1.5 cm. in thickness, and had well defined markings. The calices were well defined and not dilated. The vessels gaped on cut surfaces. There was grossly no new growth. Microscopic examination revealed well defined renal tissue, marked thickening of the

arterioles and perivascular lymphocytic infiltration.

The postoperative course was uneventful and the patient was discharged on the fourteenth postoperative day.

CONCLUSIONS

The points of importance in this case were:

1. Normal kidney function.

2. Sudden onset with no history of trauma and no evidence of internal hemorrhage.

3. Repeated hemorrhage which no doubt took place over a period of two months. Detection of the mass only at the end of that time, illustrating the chronic form of subcapsular hematoma.

4. No gross or microscopic evidence of hemorrhage of the kidney except that the perirenal vessels showed arteriosclerosis.

5. Lenk's triad of pain, pallor and renal tumor not always obvious.

6. Acute intra-abdominal catastrophes call for a consideration of perirenal hematoma.

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Science, very briefly, is a way of looking at nature, in so far as that is possible, exactly. . . . Research represents the effort men make to increase their comprehension. (Cohn)

PRIMARY CARCINOMA OF THE JEJUNUM

REPORT OF CASE

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PRIMARY carcinoma of the jejunum is of rare occurrence, although it is difficult to determine the actual number of cases in which such a diagnosis has been made because statistics pertaining to autopsy or operative findings in carcinomas of the three divisions of the small intestine are generally grouped together. According to Plunkett, Foley, and Snell[1] of the Mayo Clinic, the most common type of lesion is the annular constricting adenocarcinoma which invades all coats of the bowel. Carcinoma of the small intestine, according to reports in the literature, comprises from 1 to 3 per cent of all carcinomas of the intestine. Of the Mayo Clinic series, 41 per cent were located in the jejunum, and Carter[2] has found that 72 per cent of carcinomata of the jejunum are located in the first 12 inches.

It is very difficult to establish the diagnosis before operation, but an obstructing lesion can easily be demonstrated by x-ray studies. The symptoms are those of chronic or acute obstruction and vary with the location of the lesion. In practically all cases there is vomiting, weakness, and loss of weight.

The only treatment is resection of the lesion, and, where this is impossible, an anastomosis around the lesion will give temporary relief. The prognosis is variable. In early cases, the patients may recover after resection. No patient in the Rankin and Mayo series[2] lived longer than three years, the average being one year after the establishment of the diagnosis. Death is usually due to cachexia or obstruction.

REPORT OF CASE

The patient was a white woman, 58 years of age, who was married and the mother of two children. The family and past history revealed nothing of significance except for idiopathic gastric hemorrhage which had occurred thirty-two years previous to our examination. An appendectomy had been performed thirty years previously. When she came to the Cleveland Clinic, August 24, 1936, her chief complaints were of vomiting, loss in weight, and weakness. She apparently had been in good health until March, 1936, when she began to have attacks of vomiting, preceded by slight nausea; the vomiting gave complete relief. The attacks occurred at any time and did not seem to be related to meals or type of food ingested. Occasionally they would occur at night. The vomitus was usually light or dark green or brown and very bitter. Only occasionally would particles of food be present, although at times she would see food which she had eaten the previous day. Her appetite was good but small amounts of food would fill her up. Frequently the smell of food nauseated her. Since the onset of the present illness, she had had marked constipation; the only laxative which produced a bowel movement was Pluto water, so she resorted to enemata. No jaundice, diarrhea, bloody, tarry, mucous, or clay-colored stools, had been noted. The patient reported no abdominal pains, distress or cramps, but at times she had a feeling of fullness in the epigastrium after eating. Since the present illness began, she had noticed saliva flowing from her mouth at night when she lay on her side. Since the onset, there had been a gradual increase in weakness which had become quite marked. From June 1936 to August 1936, her weight had dropped from 184 to 145 pounds, a loss of 39 pounds.

In 1932, four years previous to this examination, the patient had noticed fulness in her neck and a roentgenogram taken elsewhere revealed a diverticulum of the esophagus in the region of the neck. At times she was able to press food from it.

Physical examination revealed a well developed, fairly well nourished white woman, who

showed evidence of recent loss in weight. The temperature, respiration, and pulse rates were normal, and the blood pressure was 120 systolic

Roentgen examination (Fig. 1) revealed an irregular deformity and constriction of the lumen at the duodenojejunal junction. This caused
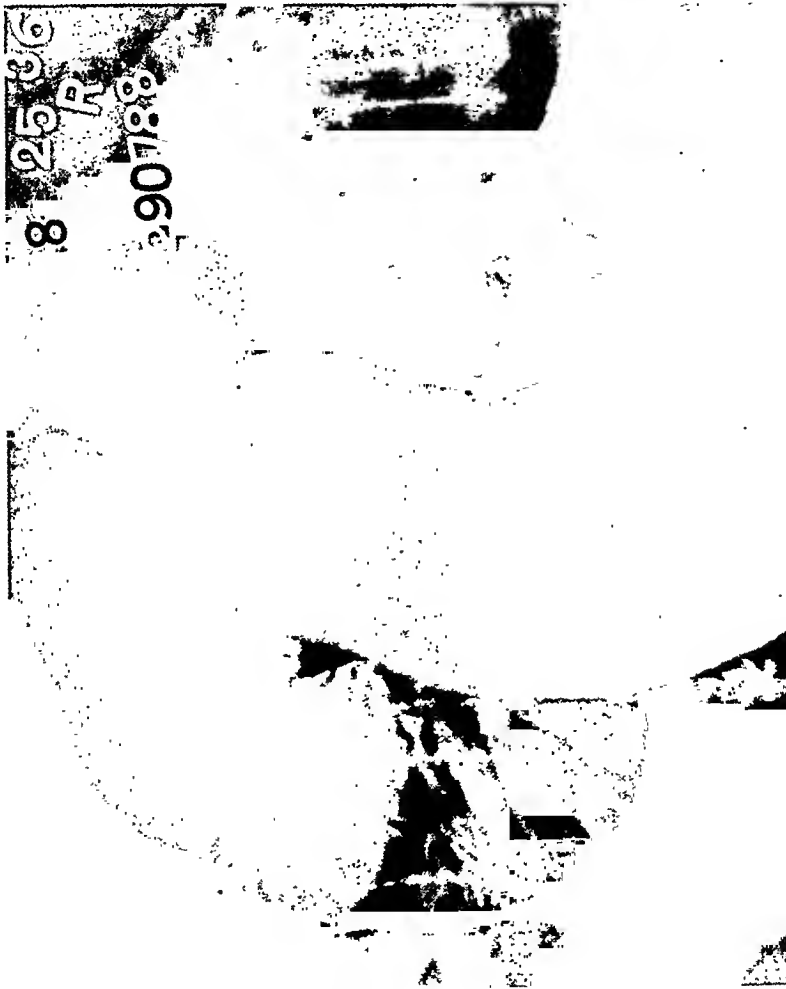
FIG. 1. Irregular deformity and constriction of the lumen at the duodenojejunal junction, causing nearly complete obstruction with marked dilatation of the duodenum proximal thereto.

and 90 diastolic. The skin and mucous membranes were of normal color and texture. The tongue was clean with neither smoothness nor atrophy. There were no palpable lymph glands. A smooth, firm, egg-sized, freely movable nodule was palpable in the right lobe of the thyroid; no other masses were palpable in the neck. Examination of the heart and lungs revealed no abnormalities. Examination of the abdomen revealed a low midline surgical scar. The walls were flat, soft, and relaxed and there was no tenderness or rigidity. No masses were palpable and there was no evidence of fluid. No further abnormalities were present except for moderate varicose veins of both legs.

nearly complete obstruction with marked dilatation of the duodenum proximal thereto, as well as a moderately large pharyngo-esophageal diverticulum. Seven-hour motility studies revealed a 90 per cent duodenal and gastric retention.

Laboratory Studies. Urinalysis on admission showed albumin and a few casts. The patient continued to have albumin and casts in her urine until shortly before discharge at which time urinalyses were essentially negative. Examination of the blood showed 5,200,000 red cells, 9,000 white cells, and 111 per cent hemoglobin (due to dehydration), whereas just before discharge there were 5,040,000 red cells,

11,050 white cells and 81 per cent hemoglobin. Examination of the stools gave essentially negative findings. Blood sugar estimation one-half hour postprandial was 143 mg. per 100 c.c., blood chlorides 478 mg. per 100 c.c., and the carbon dioxide combining power was 62 per cent. Large amounts of saline were given pre-operatively, so that following operation the level for blood chlorides was 561 mg. and the carbon dioxide combining power was 54 per cent. The urea clearance was 45 per cent the first hour and 44 per cent the second hour with a blood urea of 27 mg. Following operation, the blood urea rose to 42, but gradually returned to 30 mg. per 100 c.c.

The patient was admitted to the hospital for exploratory laparotomy. She was placed upon a pre-operative routine which consisted of liquids, hard candy, intravenous glucose, infusions of saline solution, purgatives of magnesium sulphate, enemata, and gastric lavages. The last three days before operation, a nasal tube was passed, left in situ, connected with a Wagensteen apparatus, and continuous gastric lavage was kept up by permitting the patient to drink water at will.

resected and the ends of the duodenum and jejunum were closed over respectively. (Fig. 3.) This was followed by a side to side duodeno-jejunal anastomosis. (Fig. 4.)
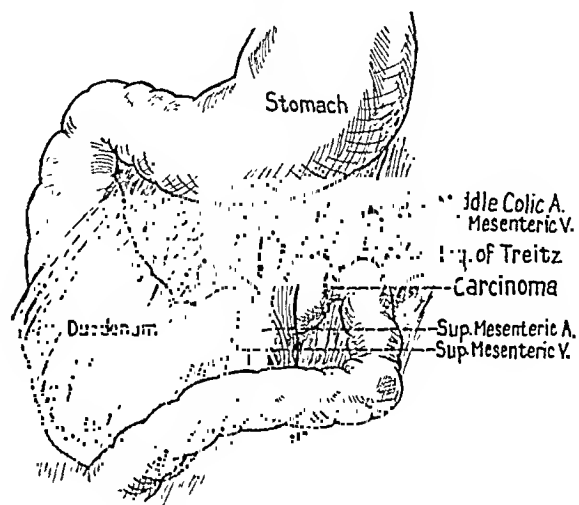
FIG. 2. Tumor mass about one inch distal to ligament of Treitz.

Pathologic Examination. The specimen consisted of a segment of small intestine including the duodenojejunal junction at the site of Treitz's ligament. (Fig. 5.) It was 7 cm. in
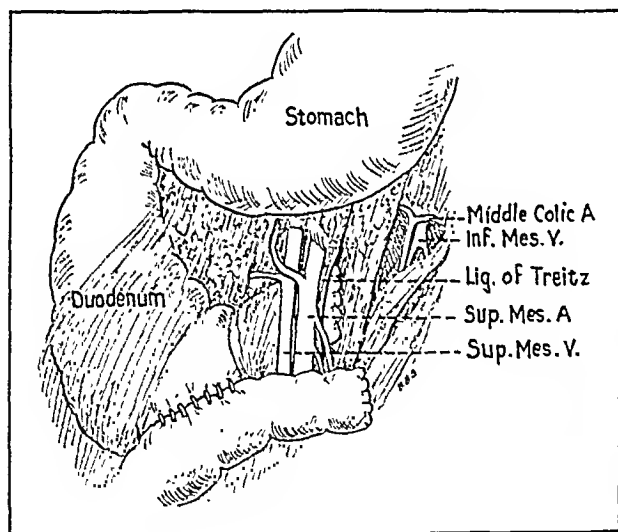
FIG. 3.
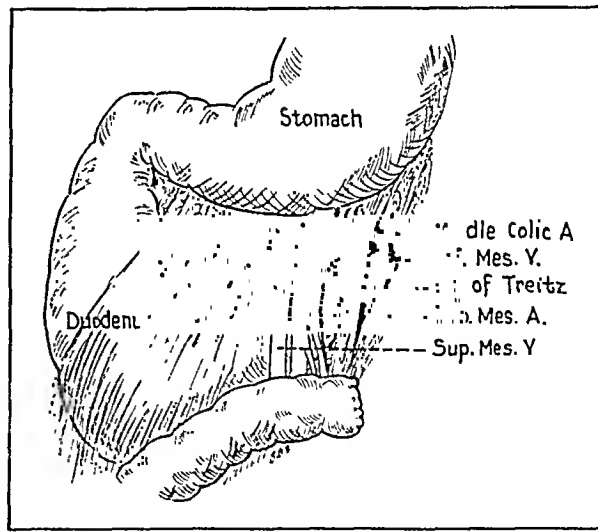
FIG. 4.

FIGS. 3 AND 4. Operative technique.

Laparotomy was performed and a stenosing tumorous mass was found approximately one inch distal to the ligament of Treitz. (Fig. 2.) It was about the size of half an English walnut and was freely movable. There were no visible or palpably involved nodes in the neighborhood of the mass. The duodenum proximal to the obstruction was markedly dilated. Seven centimeters of the duodenal-jejunal junction were

length and included a moderate amount of mesenteric fat. At the center of the segment there was a narrow circular constriction, causing marked indentation of the outer coats and a pronounced reduction of the lumen which scarcely admitted a lead pencil. On opening the intestine, a roughly circular tumor mass measuring 2.5 cm. longitudinally and 2.5 cm. transversely was found on the mesenteric border

It involved about two-thirds of the circumference of the intestine. The gross appearance was that of an adenocarcinoma. Microscopic ex-

FIG. 5. Wax model of specimen, consisting of a segment of small intestine including duodeno-jejunal junction at site of Treitz's ligament.

amination (Fig. 6) revealed a section of the jejunal wall covered on one end by practically normal mucosa and on the opposite end an adenocarcinomatous growth originating in the mucosa, infiltrating all of the coats, and extending directly into the mesenteric fat.

The patient stood the operative procedure satisfactorily, and following the operation she was given a transfusion of 500 c.c. of whole blood, while the continuous intravenous administration of 5 per cent glucose in saline solution was started. On the third post-operative day, the nasal tube was removed and fluids were given by mouth. Although she took fluids satisfactorily, she was nauseated and vomited frequently due to regurgitation from the esophageal diverticulum. On the fourth post-operative day, the continuous intravenous infusion of fluids was discontinued. The following day, an attack of vomiting resulted in rupture of the abdominal wound. Following repair of this, she had a very smooth convalescence and was discharged twenty-three days after operation at which time she had no complaints and was able to eat anything without the slightest discomfort.

The patient has been seen once a month since operation and the last time she was seen she weighed 163 pounds, a gain of 18 pounds. The appetite was good and it has been necessary to resort to laxatives only occasionally. She had no complaints whatsoever and her condition was considered as excellent, except for a little trouble due to the diverticulum of the esoph-

agus, which will be excised after sufficient time has elapsed to be fairly certain that recurrence has not taken place.

FIG. 6. Photomicrograph showing adeno-carcinoma of jejunal wall. (× 150.)

SUMMARY

The difficulty of early diagnosis of carcinoma of the jejunum is reflected in the curability rate. Even early Roentgen therapy is of little value because a considerable degree of obstruction must be present before it is manifest and, frequently by this time, some extension has taken place. Routine examination of the stool for occult blood and insistence on early exploratory operation in the absence of definite Roentgen findings seem to offer the only hope of detecting these cases earlier so that the curability may be increased.

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BONE GROWTH FOLLOWING AMPUTATION IN CHILDHOOD*

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IN the spring of 1935 we assumed the orthopedic service at a Home for Crippled Children. Among the many cases there, we found eight amputation cases, six involving the leg, one involving both humeri, and the other a disarticulation through a knee.

These eight cases illustrated a phenomenon that we had never previously met, i.e., natural growth of bone from the remaining superior epiphysis of all the cases except the knee, and here both epiphyses were functioning. This normal growth had created difficulties with the stumps. These cases were discussed with a number of surgeons whose experience had extended over a long period; they had never met this problem. Following these discussions, a large number of textbooks, both old and modern, were consulted, particularly in regard to the leg amputations, and nowhere was the problem of post-amputative bone growth considered. We found in the text a variation as to flap formation, but all were in accord as to the treatment of the bones themselves. The fibula must always be sectioned at a higher level than the tibia. With this preponderance of written opinion we must accept the higher section of the fibula as a standard procedure.

A review of the literature was equally sterile. Apparently this condition has been observed and never considered worthy of mention, or else no one has previously observed the condition. These would seem to be the only explanations for the lack of literary reference. In either event, this series of cases appeared to us to be of sufficient importance to be reported.

This report is based upon six males between the ages of 10 and 14 who had previously lost a portion of the leg, in varying positions from the junction of the lower and middle thirds to the junction of the middle and upper thirds. In all of them there were "pencil" stumps and in all of them the fibula had outgrown the tibia 2 to 4 inches. This in itself was a peculiarity, as we have been led to believe that the superior tibial epiphysis was one of the most active, if not the most active, epiphysis in the body. If this supposition was correct the natural corollary would be that in the case of amputation affecting both bones of the leg the tibia would outgrow the fibula, instead of the reverse condition.

The supposition is that the standard procedure was followed, i.e., the fibula was cut at a higher level than the tibia. These cases have come to us from various regions, and it is hardly likely that any of the operators cut the tibia shorter than the fibula. In fact, most of these patients had worn artificial legs before admission, but could no longer wear them when seen.

The question arose as to why this overgrowth had occurred. One could not blame prosthesis pressure as a stimulating factor, as this pressure would have affected the tibial tuberosities to a much greater degree than the fibular head. It is doubtful that the original trauma affected the growth, since had this been true, the tibia should have been as much involved as the fibula. Certainly end pressure from a prosthesis is

not an answer, as in normal amputation the tibia will bear the majority of end weight. In these cases it was impossible to wear a prosthesis after the fibular growth had exceeded the tibia.

It would seem evident from this series that sufficient attention has not been paid to the superior fibular epiphysis as a factor in normal growth, but that most of the attention has been directed toward the larger and apparently more active superior tibial epiphysis. Must our preconceived ideas be revised?

In treating the four longer stumps, we made a lateral incision over the fibula, exposed it and cut it 2 inches shorter than the tibia; in two of these cases, it was also necessary to redress the lower end of the tibia which had become sharpened. In the two shorter cases lateral incisions were made and the entire fibula removed. In the first one of these no drainage was used in the space where the tibia had been and considerable swelling resulted, making it necessary to remove two sutures for drainage purposes; there was no infection but full healing did not occur for one month. In the second case, done some time later, drainage was placed and no postoperative swelling occurred; there was healing within two weeks. All of these patients have been able to wear artificial limbs with comfort since operation and all but one have been discharged to their homes (that one had no home).

One patient with disarticulation of the right knee pointed a moral in such cases during the growing period. He was twelve years of age, and had been operated on three years before we saw him, as a result of vehicular trauma. For two years he had been comfortable, but in the third year the lower end of the stump began to ulcerate. At first the ulcers would heal after the artificial limb had been removed, but later they failed to heal even in the absence of end pressure. Finally, the remaining articular cartilage was exposed, and the skin over the entire end of the stump was tight and atrophic.

This problem was met by a Gritti-Stokes procedure, even though we realized that we were removing an important epiphysis. The patella failed to unite to the lower end of the femur and slipped back to its anterior position. The patient had voluntary control of the patella and would move it at will with a great deal of satisfaction. An artificial prothesis was fitted with entire comfort. Two years have elapsed and, from reports from the boy, he is perfectly happy and as active as one could desire. There has been no further discomfort with his stump. This brings up a point regarding the Gritti-Stokes amputation: is fixation of the patella over the femoral end an absolute necessity?

The high humeral amputation showed abundant soft tissue stump, but large spicules had grown from the bone and had penetrated the skin of the flap leaving the tips of the spicules exposed with resulting sinus formation. Here the procedure was simple. The spicules were removed at the level of the bone stump, the case requiring no further care. We have had no reports from this boy, but we believe that there has been no further discomfort. In the treatment of an acute case involving both bones of the leg immediately after accident in a child, based upon the observations reported, we would not hesitate, in the presence of a short leg stump, then and there to remove the fibula in its entirety. It is simply and quickly done, and no attention need be paid to the peroneal nerve as its functional control is no longer necessary. The procedure is practically without shock. As drainage must be used in stumps, the problem of draining the site of fibular excision would not have to be handled as a separate and distinct factor. In longer stumps it would seem quite wise to cut the fibula at least 2 inches shorter (more would be better), a long, soft-tissue flap being provided to take care of bone growth later. The condition is utterly different from that in the adult, where bone growth has ceased. Not only should the long soft tissue

flap be left in two-boned sites, but also where there is a single bone, for growth is bound to occur, and as it continues trouble will follow as in the case reported. We have pondered over the problem of the single bone or disarticulation and we have reached the conclusion that should such a case present itself, rather than to disarticulate, we would amputate above the lower epiphysis with an abundant soft tissue flap.

SUMMARY

Six cases of amputation in childhood through both bones of the leg are reported, with apparently unexplainable fibular overgrowth. The treatment has been outlined and a suggestion made as to the immediate procedure at primary amputation. A case of femoral growth and resulting stump difficulties has been discussed and a primary procedure for prevention of this difficulty has been offered.
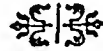
THERE is an old medical proverb which was frequently repeated by Dr. Osler. . . . "It is much more important to know what sort of patient has a disease than what sort of disease a patient has." (Walsh)

SARCOMATOUS DEGENERATION ON A VARICOSE ULCER*

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W E report an exceptionally rare case of sarcomatous degeneration on a varicose ulcer of the leg. A thor-

Fig. 1. Varicose ulcer with fungating hemorrhagic growth; appearance before amputation.

ough search of the literature has revealed only two instances of this pathology; one case, a fibrosarcoma, was similar to ours, while the other proved to be a round-cell sarcoma. It would therefore appear that our case is the second on record of a fibrosarcoma implanted on a varicose ulcer. Although it is not uncommon to find carcinomatous degeneration associated with irritation (we have seen two such cases),

sarcomatous changes in the skin are a rarity.

In 1884 Prewitt reported his case of fibrosarcoma which was implanted upon a varicose ulcer of many years' duration. The gross appearance was that of a fungating growth. There was metastasis to the inguinal glands, and many tortuous varicose veins were present. The biopsy report was to the effect that "tumor is firm and elastic. Cut surface shows bands of firm white fibrous tissue in a semi-translucent mass. This latter exudes a serous mucous or fluid, yet is firm; not at all soft. This translucent portion is changed, in appearance, to white fibrous tissue by the action of alcohol. The microscopic appearance is to a certain degree heterogeneous. Section from the surface is composed of granulation and cicatricial tissue. On the edge of this section is a group of cells resembling the cells of alveolar or net-celled sarcoma—fibrosarcoma."

Donati's case also had varicosities with ulceration of long standing, covered with a cauliflower-like growth. After biopsy the diagnosis of round-cell sarcoma was made. This was of further interest because the patient had a simultaneous carcinoma of the left breast.

The subsequent course of the degeneration in the above two cases was not reported.

CASE REPORT

E. M., age 69 years, a leather worker, was admitted to the hospital May 26, 1937 because of an ulcer of the left leg of many years' duration.

His family history was irrelevant. He had had an occasional cough, but no serious illness or operation.

The upper end of the ulcer was fungating (about two months?) and had hemorrhaged slightly. The only history of irritation was the use of silver nitrate applications.

Fig. 2. Polymorphous cellular tissue; elongated cells with dark oval nuclei and tapering ends; pleomorphous cells with hyperstaining nuclei and occasional mitoses. Diagnosis: Fibrosarcoma.

The patient was not acutely ill. Head, face, nose, mouth and ears were grossly normal. The pupils were small and reacted well to light and accommodation. The neck was normal, the chest clear, the heart slightly enlarged, with regular sinus rhythm and no murmurs. Blood pressure was 135/90. Abdominal organs were palpable. The genitalia were externally normal.

The left leg had a circular atrophic ulcer, showing little tendency to heal, located on the anterior aspect and extending to the mesial and lateral sides at mid-level; the upper end of the ulcer was fungating and hemorrhagic. Trophic discolorations were present on the right leg, but no ulceration. Palpable dorsalis pedis pulsation was noted in both extremities, more definitely on the right. Moderate varicosities were present in both legs.

The diagnosis was varicose ulcer of the left leg.

X-ray examination showed no pulmonary infiltration or consolidation. The heart was enlarged and the aorta prominent. X-ray of the left leg disclosed periosteal thickening with cortical irregularity of the posterior margin of the fibula. No other gross bone changes of the left leg were observed.

Wassermann reaction was negative. The urine and blood chemistry were normal.

Two days later, on top of an old, nearly circular ulcer of the left leg there appeared a large ulcerated surface about 2½ inches in diameter, showing exuberant glassy granulations overlying a base of partly necrotic fibrin. There were no palpable inguinal lymph nodes. The impression was one of malignancy (epithelioma).

On June 8, a biopsy was made of the ulcer granulations. The area bled easily on traumatization and showed little or no tendency to heal. The pathologic report mentioned the hemorrhagic and ulcerated surface, and described the specimen as cellular tissue, polymorphous in type. Most of the cells were

elongated, with dark, oval nuclei and tapering ends, resembling fibroblasts. There were other cells, with vesicular, round, hyperstaining nuclei. A considerable number of blood vessels were present. There was also a considerable amount of leucocytic infiltration. The general appearance was that of granulation tissue. However, the occurrence of pleomorphous cells with hyperstaining nuclei and occasional mitoses, spoke for a more active neoplastic process. The pathologic diagnosis was fibrosarcoma.

On June 18 the patient was confined to bed. The ulcer, nearly completely circular, extended down to the bone and eventual healing seemed improbable. In the absence of demonstrable metastasis, amputation was indicated, and consultation with the cancer division confirmed this opinion.

On June 21, under spinal anesthesia, the left leg was amputated above the knee. A circular incision was made about 2 inches above the knee. The skin was allowed to retract and the muscle was cut through at a higher level. The bone was sawed through about 3 inches above the skin incision level, the periosteum and endosteum curetted, and bone wax applied to the cavity. The vessels were ligated individually. The skin was sutured with interrupted tension sutures after the soft tissues were approximated with chromic mattress sutures.

After operation, skin traction was used on the stump; clyses and heat were applied. The wound healed by primary union within two weeks.

Four months following amputation the patient was in apparent good health, and there was no evidence of metastasis.

SUMMARY

We have reported a case of sarcomatous degeneration on a varicose ulcer, which is of exceptional interest because of its rarity. It is the second fibrosarcoma associated with varicose ulcer to appear in the literature.

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PYLORIC STENOSIS FOLLOWING THE INGESTION OF TINCTURE OF IODINE

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THE corrosive effect of certain caustic fluids, when ingested either accidently or with suicidal intent, is a subject of considerable clinical importance, presenting a variety of problems influencing both recognition and treatment. The results of such a violent chemical insult to the upper alimentary passages vary from small ulcerations of the mouth and pharynx, when only a small amount of the offending substance is taken, to extensive destruction of large portions of the esophagus and stomach with prompt exitus, when a large dose is taken. The immediate treatment of such poisonings is beyond the scope of this communication. We are here concerned with one of the later sequelae in the cases which have survived the immediate escharotic effects.

Esophageal stricture is generally considered to be the ordinary result in most of such instances. Attention should be drawn to the fact, however, that a similar effect may take place in the pylorus which is of considerable clinical importance. This may occur either alone[1,2,3] or in association with esophageal stricture.[4,5]

Mechanism. Selective pyloric involvement has been attributed by Samaja[6] to a series of reflex tetanic contractions of the gastric wall which tends to concentrate the caustic fluid in the pyloric antrum. Boikan and Singer[7] point out that the presence of an air bubble in the stomach may protect the cardia and fundus at the expense of the pylorus. They also make the observation that the squamous cell epithelium of the esophagus is particularly vulnerable to alkaline escharotics such as lye, and that it is much less so to the acid caustics. This is in accord with the clinical observation that esophageal stenosis generally follows ingestion of alkalies while pyloric stenosis occurs after ingestion of acids. We have been unable to find any recorded cases of esophageal or pyloric stenosis following the swallowing of tincture of iodine other than our own case reported herewith, and we note that in its selective localization the iodine acts as an acid.

CASE REPORT

H. B., a 32 year old white man, was admitted to Bronx Hospital, June 30, 1936. Five months previously he had taken a large dose of tincture of iodine with suicidal intent. He had recovered from this episode, returned to his usual occupation, and remained well until two months before admission to the hospital when he began to experience anorexia and a sensation as if food were "stuck in his stomach." This was followed shortly thereafter by the appearance of nausea, eructations, and finally by vomiting. The vomiting usually occurred in the evening; and the vomitus generally consisted of large amounts of sour gastric contents containing partially digested food. The patient had never noticed any hematemesis, melena, or spontaneous abdominal pain. There was a loss of 6 pounds in weight during the two months preceding his admission to the hospital.

The physical examination of the patient revealed a poorly nourished individual, but there were no unusual physical findings. The urine was normal. The red blood cell count was 5,080,000; the hemoglobin was 68 per cent of the normal. The Ewald test meal revealed a total gastric acidity of 63 and a free hydrochloric acid content of 45. There was no lactic acid or blood in the stomach contents.

Gastrointestinal x-ray studies revealed an extremely dilated and ptosed stomach with a filling defect in the region of the antrum and duodenal cap. There was extreme delay in gastric evacuation, the forty-eight hour examination showing retention of almost the entire barium meal within the stomach. No abnormalities of the esophagus were noted. A barium enema revealed no abnormalities other

than a downward displacement of the splenic flexure by the dilated stomach. The roentgenologist felt that these findings indicated the presence of either an extrinsic or intrinsic neoplastic pyloric obstruction.

Following a period of preoperative preparation with gastric lavages and the administration of intravenous glucose infusions, the patient was operated upon. The abdominal exploration revealed an enormous dilatation of the stomach due to a tight stricture at the pylorus. There were no gross evidences of neoplasm or peptic ulcer. The remainder of the abdominal cavity and its contained organs seemed normal. A posterior, retrocolic gastrojejunostomy was performed.

The postoperative course was entirely uneventful. Vomiting stopped immediately and the patient left the hospital on the fifteenth day after operation. Since then he has gained weight and improved in every way. There have been no subsequent gastric symptoms of any kind.

Pathology. The immediate local effect of a caustic is the production of areas of necrosis with secondary ulceration of varying depth. The mucosa is usually destroyed completely and the necrotizing process extends to the submucosa and muscularis. Occasionally the serosa is also involved with resultant perforation of the viscus. The adjacent portion of the walls of the stomach becomes thickened and deformed, and the replacement fibrosis usually leads to the formation of a tight inelastic stricture at the pylorus. Occasionally this resembles grossly, a scirrhous carcinoma. At times, the lesion develops proximally to the pylorus and results in an hour-glass deformity of the stomach.[8]

Such changes necessarily result in prolonging the emptying time of the stomach. Secondary compensatory changes including gastrectasia and hypertrophy of the gastric wall ensue. In most cases complete pyloric stenosis supervenes with fatal outcome unless the mechanical obstruction is relieved by operation. In the case reported by McLanahan[9] the stenosis had become so complete that post-mortem examination of the specimen revealed a complete occlusion both anatomically and functionally.

Histologic examination reveals extensive connective tissue replacement with evidences of active gastritis as late as six months after the ingestion of the caustic. In most cases, however, gastric mucosa regenerates although there appears to be a subsequent reduction in its ability to secrete hydrochloric acid. In Putnam's[10] case there had apparently been a complete destruction of the gastric mucosa which, during the reparative stage, had been replaced by squamous epithelium growing downwards from the esophagus.

Clinical Picture. Following recovery from the initial effects of the poison, the patient generally makes a rapid recovery and is often discharged from the hospital in almost normal state. Symptoms of pyloric stenosis generally begin to make their appearance about four weeks later, although latent periods of five[11] and six[12] years have been recorded in the literature. Nausea becomes a prominent symptom and is soon followed by occasional vomiting which quickly becomes repeated with greater and greater frequency. Then the general signs of inanition and dehydration appear and unless the condition is relieved death eventually results.

Roentgen examination usually reveals a marked pyloric stenosis, at times of an irregular configuration very similar to the roentgenographic appearance of an obstructing pyloric carcinoma.

The diagnosis can usually be made on the basis of the history, but even this may not be sufficient to exclude the presence of an independent pyloric neoplasm.

Treatment. The therapeutic management of this type of pyloric stenosis must be surgical. The various procedures which have been advised can generally be classified into four groups.

1. Manual dilatation of the pylorus through a gastrotomy was suggested by Loreta[13] and by White and Lane;[14] but the method is very unsatisfactory and has been given up entirely.

2. Pylorectomy was performed by Czerny[15] and Monprofit[16] after unsuccessful attempts at manual dilatation of the pylorus. This method was also used by von Eiselsberg.[17] At present, however, it is felt that so radical a procedure is unwarranted unless it is impossible to differentiate the cicatricial mass from a malignancy during the course of a laporotomy, as happened in Putnam's case. Furthermore, as Schmieden[18] points out, the inflammatory changes in the gastric wall may cause considerable difficulty in the extensive suturing necessarily incident to this operation.

3. Pyloroplasty according to the Heinecke-Mikulicz[19] technique has been used with varying success by a number of operators, including Mikuliez,[20] Colzi,[21] Postempski[22] and others; but in this procedure, as in pylorcetomy, the technique is unnecessarily complicated and the suture line precarious due to the damaged state of the involved tissues. This operation has not been practiced in recent times.

4. Gastrojejunostomy seems to be the most rational method of overcoming the pyloric stenosis. In competent hands it is attended by the lowest mortality; its performance does not require incision into scar tissue; and, when properly made, the new stoma permits a return to as normal a gastric physiology as is possible. According to Koellner[23] the first gastrojejunostomy for pyloric stenosis due to poisoning was performed by Monastyrski[24] in 1884. One year later Sklifossowski[25] also attempted this procedure. Both of their patients died. Quénu[26] and subsequent surgeons, both American and foreign, have been more fortunate, so that gastrojejunostomy is now recognized as the operation of choice for this as well as other forms of cicatricial pyloric stenosis.

It is, of course, highly advisable to prepare this type of patient for operation as well as his condition will permit. Boikan and Singer[7] recommend that an attempt be made to postpone operative treatment until six months after the original poisoning if this is feasible, the maintenance of the patient's nutrition being meanwhile accomplished by a high calorie liquid diet. This is done in order to allow the original gastritis to subside as much as possible. While this is a reasonable suggestion, we feel that one should not be bound by any arbitrary time limit and that care must be taken not to allow the general condition of the patient to become so debilitated by any prolonged period of semi-starvation as to endanger recovery from the necessary operative interference. Once the initial violent inflammatory changes have subsided it seems better to operate while the general nutrition is still good even though the gastritis has not completely subsided than to wait until there is complete anatomic restitution to the normal at the cost of marked impairment of the general nutrition. Such considerations relating to the optimum time for operation must vary with the individual case and call for accurate judgment on the part of the surgeon.

Parenteral fluids and transfusions of blood form an essential part of the pre- and postoperative treatment and are to be administered according to well established indications. Preoperative gastric lavages are likewise of value, not only in diminishing the degree of gastric stasis, but in improving the tone of the dilated stomach.

Occasionally the condition of the patient is so poor that an attempt at gastrojejunostomy would be unduly hazardous. Rieder[27] has suggested a preliminary jejunostomy for feeding purposes in such cases to be followed at a later date by gastrojejunostomy. This procedure has also been followed by Kanno and Seian[28] and by Bruce.[29] These observers report complete satisfaction with it in selected cases.

SUMMARY

1. Attention is directed to a fairly common syndrome of pyloric stenosis following ingestion of corrosive liquids.

2. A case in which tincture of iodine produced this lesion is recorded.

3. Gastrojejunostomy preceded, if necessary, by jejunostomy, is recommended as the procedure of choice in the surgical correction of the condition.

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NEW TECHNIQUE IN TREATMENT OF DUODENAL FISTULA

REPORT OF CASE

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THIS case is reported because it demonstrates a new use for the capillary drain reported by Thompson and Wright,[1] and also because with this technique the time required for closing of the fistula is much more rapid than with other techniques reported in the literature.

effluent solution is handled. In the case herewith detailed, neutralization was replaced by dilution, and suction was used,

Fig. 1. Note catheter lying in wound. Zinc oxide on skin, oiled silk next, then rubber ring. Wound at time of closure of fistula.

The general consideration of duodenal fistula has been well presented in papers by Potter,[2] Kittelson,[3] and others. This paper, therefore, mentions only the work which used principles embodied in the technique herein described.

Erdman[4] in 1921 advocated jejunostomy, suction, and large amounts of water by mouth. Potter advocated irrigation of the fistula with $\frac{1}{10}$ normal hydrochloric acid, 20 to 60 drops per minute, and the use of the duodenal tube by mouth. In his papers he does not mention how the

employing the capillary drain. It is not my purpose to criticize neutralization as a principle. In this case it was not needed.

CASE REPORT

A male, age 54, on June 10, 1937, arose at 3:00 A.M. After taking a drink of water, he was stricken with a sudden pain, so severe that he fell to the floor and was unable to return to bed. Medical attention was quickly obtained and a diagnosis of gallstone colic was made. Large amounts of pain-relieving medicine were used, but the pain lasted for about four days, following which the patient suffered from nausea and complete loss of appetite. At the end of three weeks, he was still suffering, and at this time a gall-bladder x-ray revealed a gall-bladder which filled and emptied, with no stones visual-

ized. The patient was referred to the writer at this time.

He had had nausea and epigastric pains at

ture. Four successive pictures showed the lesser curvature constant in outline and the greater curvature variable. The leucocyte

FIG. 2. Flat gauze over wound to filter out solids in wound secretions. End of capillary drain placed on gauze.

FIG. 3. Gauze turned in to be entirely within the rubber ring. Zinc oxide ointment spread around ring.

intervals for three years, for which he used Sippy powders. The temperature was 101°F. There were epigastric splinting and tenderness. An intravenous pyelogram was negative. X-ray examination of the stomach revealed that the lesser curvature was fixed. Peristaltic waves were visible only on the greater curva-

count was 19,000, with 94 per cent polymorphonuclears. On the basis of these findings a diagnosis was made of ruptured duodenal ulcer with residual abscess at the lesser curvature of the stomach.

At operation on July 2, the abscess containing about 4 ounces of pus, was found. The gall-

bladder was surrounded by adhesions, but was otherwise normal. In the vicinity of the duodenum there was a granulating area, but no

was dressed with powdered milk. On July 8, the wound was not improved and the dressing method was changed. The capillary drain, as

Fig. 4. A second, smaller sheet of oiled silk covers other parts of dressing. Zinc oxide covers capillary drain where it leaves the oiled silk.

Fig. 5. Cellucotton covers edges of second sheet of oiled silk.

perforation was visible. Drains were placed and the wound closed.

Twelve hours after operation the dressings were found to be saturated with clear fluid, later followed by fluid with a yellowish sediment. Digestion of the wound was not very extensive until July 6, at which time the wound

described by Thompson and Wright[1] was used. In twenty-four hours, 1,025 c.c. of drainage was collected. This of course did not include fluid saturating the dressing.

The capillary drainage had no visible effect on the wound. On July 10, the wound was continuously flushed with normal salt solution

using 120 drops or more to the minute (over 10 liters in twenty-four hours). Following this the wound rapidly improved in appearance and crater rapidly healed, leaving a narrow sinus which discharged a small amount of pus for six weeks more, then healed completely.

FIG. 6. First sheet of oiled silk is folded over the dressing. Large sheet of cellu-cotton placed over entire dressing.

FIG. 7. Many tailed binder placed over dressing. Murphy drip container provides a flow of 120 drops or more to the minute.

four days later the duodenal drainage stopped completely. At this time the wound was rapidly granulating. Urinary output tripled when the fistula closed. A purulent discharge continued for another week until a mass of brownish material, interpreted as inspissated duodenal content, was forced out of the wound. The

DETAILS OF DRESSING

Details of the dressing are illustrated in Figures 1 to 7.

The capillary drain is made by using a Penrose drain rubber tube one yard long. A square yard of gauze is rolled into a uni-

form cylindrical roll and drawn through the Penrose rubber tube. The gauze extends 3 or 4 inches beyond the rubber tube at the end which is placed on the wound. In the upper angle of the wound is placed a small rubber tube which carries the Murphy drip solution, and around the wound there is a ring of zinc oxide ointment. A square of oiled silk with a circle cut out at the center is pressed down on the zinc oxide ring, making complete contact all around the wound. On top of the oiled silk we place a ring of rubber tube with the ends held together by a safety pin (the safety pin part of the ring is placed above). Zinc oxide ointment is then packed around the rubber tube and a flat gauze dressing inserted over the wound inside the circle of rubber tube.

A capillary drain, described above, is thoroughly soaked in sterile water and is then fixed with one end on the flat gauze and the other end in the bottle at the side of the bed. Another sheet of oiled silk, smaller in size than the first, covers the dressing and is pressed carefully into the zinc oxide. Around the margins of this square of oiled silk are strips of cellucotton, with the edges of the first piece of oiled silk folded over them. A large pad with lacings to hold it in place and the usual binder, completes the dressing.

This rather elaborate dressing allowed constant irrigation of the wound with a fairly fast flow of normal salt solution without causing the patient to suffer from the seepage of more than a small amount of fluid from the dressing. Very often the patient remained completely dry, except for the dressing, for hours at a time.

CONCLUSION

The capillary drain makes it possible to use extreme dilution in the treatment of duodenal fistula.

Doubtless other conditions will be found which will be benefited by use of these principles.

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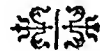
PLASMA CELL MASTITIS: A PATHOLOGIC ENTITY*

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OF all those inflammatory states to which the breast falls heir, plasma cell mastitis most frequently and consistently masquerades as cancer. The term "plasma cell mastitis" is given to a subacute or chronic inflammation of the breast characterized by a rich plasma cell exudate. It was first noted and described by Ewing and his observations correlated with a clinical entity established by Adair in a study of ten cases. Undoubtedly, it has chagrined the surgeon and confounded the pathologist in the past. The former has generally considered it carcinoma and the latter, although he has observed and probably recorded the unusual plasma cell infiltration, has grouped the process under the non-specific inflammatory states of the breast.

Cutler has reviewed the older literature and failed to find any reference to acute or subacute inflammatory states of the non-lactating breast with the exception of those noted in complicating infections such as typhoid fever or parotitis. Clinically, the features of plasma cell mastitis appear to have been noted by Courtin in 1899. He observed a breast lesion with skin fixation, nipple retraction and axillary adenopathy accompanying a mass in the breast of a 50 year old female. After four weeks of local applications, the mass disappeared. Coquet, discussing this case, reported a similar case. Neither report was accompanied by histologic studies. It remained for Adair in 1933 clearly to present this inflammation of the breast as a clinical entity. Since then the surgeon has been stimulated to differentiate this process, and both Cutler and Moore have reported cases. Others have undoubtedly been observed but not recorded. As yet the pathologic aspects have not received much attention in the literature of pathology.

ETIOLOGY

Although large cocci growing in pairs or short chains were isolated in four of Adair's cases, infection was thought to play a less prominent rôle in the etiology than that played by chemical irritation from stagnating breast secretions, the converse of suppurative mastitis. Two cases showed gross pathology, and a third presented a histology suggesting tuberculosis, but guinea pig inoculations were negative.

The average time since last lactation was four years, but this seemed to have no bearing on etiology. On the other hand, in no case did plasma cell mastitis occur in an unmarried woman. There was an average of four pregnancies in each patient. Adair believes that this is strong support of improper breast drainage as a cause of the process.

In Adair's ten cases the age range was from 29 to 44 years, with an average of 36.3 years. Cutler's patient was 50 years of age.

GROSS PATHOLOGY

In Adair's ten cases, nipple retraction occurred in 80 per cent, skin adherence in 60 per cent, enlarged axillary nodes in 80 per cent, peau d'orange appearance in 40 per cent, and in 70 per cent creamy purulent material could be expressed from the nipple.

The mass in the breast is usually either very firm or hard. It varies from a sharply defined area to an ill defined but localized mass. The lesions have averaged 4 to 5 cm.

in diameter, the largest being 8 × 8 × 10 cm. In one case the axillary mass was 4 cm. in diameter.

lack of cicatrization or chalky streaks, and dilated ducts are all compatible with an inflammatory process.
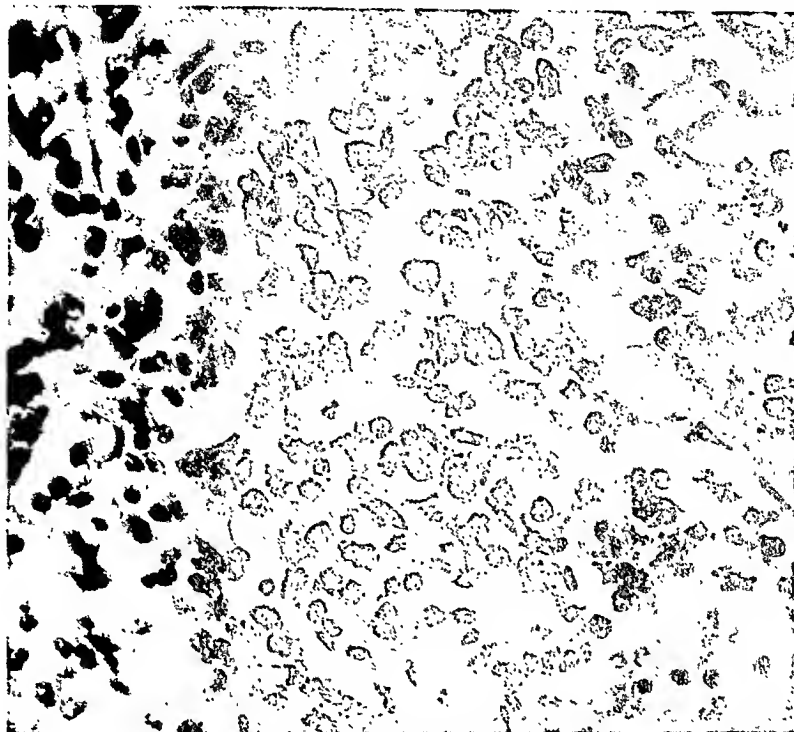
Fig. 1. Plasma cell mastitis. A high power field showing the plasma cell infiltration and the giant cell formation.

On cut section, the breast will show numerous dilated tortuous ducts and small cysts containing thick grayish creamy material. This duct process is often diffuse. The tumor area presents radiating strands of dense translucent fibers, often with a pinkish inflammatory appearance. Small necrotic foci may be seen. The main mass is often very dense and almost cartilaginous. In one case Ewing observed chalky streaks in the radiating fibrous tissue, but this is rare and seldom causes confusion with cancer. Often the cicatricial tissue is grossly suspicious of malignancy and by palpation alone it may be impossible to distinguish it from carcinoma. Peculiar ochre yellow points and xanthomatoid foci 1 to 3 mm. in diameter have been seen. These are not purulent or semifluid, yet are not firm enough for tumor tissue. The mass may be found at the apex of a radiating group of dilated ducts. The diffuseness of the mass, absence of a discrete tumor, creamy discharge from the ducts, frequent

HISTOPATHOLOGY

Microscopically, the most striking feature is the inflammatory exudate which is preponderantly plasma cell in type. With this is, however, often a distinct polymorphonuclear neutrophile infiltration and some lymphocytes, but the unusual number of plasma cells is impressive. The reaction involves both the glandular and the interstitial elements, but is especially prominent around the ducts where it consists of almost pure plasma cells. The large ducts are distended with purulent cellular débris, while the smaller ducts in addition, present lumens partially obliterated by a desquamative epithelial hyperplasia. The picture often resembles, in this hyperplasia, comedocarcinoma for which it has been mistaken. The walls of the larger ducts are seen to be infiltrated with plasma cells, even to the extent of obliteration of the normal duct architecture.

Where small xanthamatoid foci are seen, they are very cellular, being composed of

large round to polyhedral cells with lipoid material distending them. These foci may be attended by polymorphonuclear cells

for such, a paraffin section shows the process to be confined within the walls of the ducts and acini. On frozen section, the
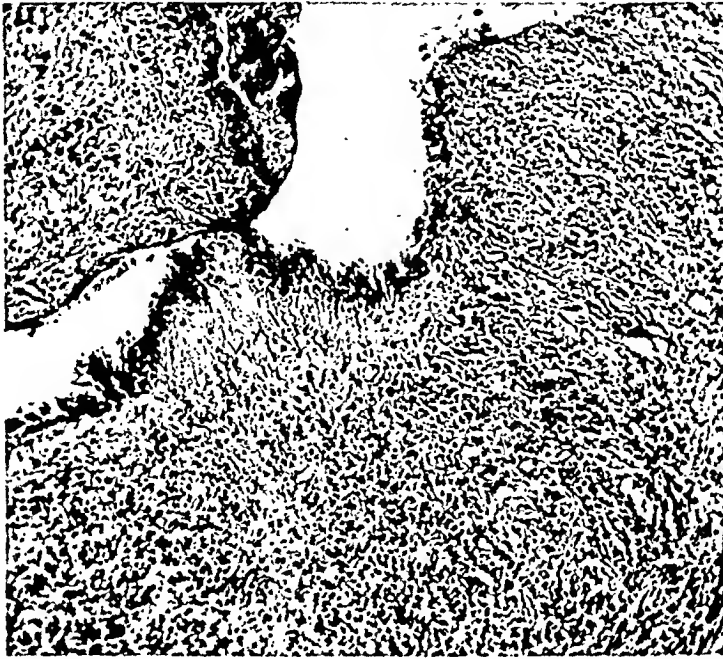
FIG. 2. Plasma cell mastitis. A low power field showing the inflammatory reaction about a duct.

and form miliary abscesses. All foci contain plasma cells which, in addition, infiltrate the stroma in sheets, cords and avoid masses. It may be so extensive as to blot out the glandular configuration of the tissue.

Diffuse growth of young connective tissue often accompanies the process and dense reactive fibrosis occurs. This extends out into the more normal breast and supportive tissue, accounting for the adhesive and retractive gross features suggesting cancer. Intermingling with the cellular reaction are frequently seen giant cells which may form conspicuous sheets infiltrating the stroma along with the plasma cells. These giant cells of foreign body type are often encountered where there is marked epithelial hyperplasia. In one case, the configuration of the giant cells and the fibrous reaction resembled miliary tubercles.

Although the epithelial hyperplasia may undergo such changes as to resemble cancer, and on frozen section be mistaken

disorderly and atypical epithelium appears at times to have invaded the surrounding tissue. Again, the large edematous plasma cells and giant cells, poorly fixed on frozen section, may resemble small infiltrating carcinoma cells.

DIFFERENTIATION

Except as noted above, it is uncommon to confuse plasma cell mastitis histologically with malignancy. In the presence of extensive desquamative epithelial hyperplasia with comedo formation, the presence of malignant cells beyond the confines of the duct and acinar walls must be excluded.

Usually the preponderance of plasma cells in the inflammatory exudate serves to distinguish this entity from such confusing processes as chronic lactation mastitis, traumatic fat necrosis of the breast, tuberculous mastitis, syphilitic mastitis and various forms of non-specific subacute and chronic inflammatory masses.

The abscess and draining sinus will in many cases rule out plasma cell mastitis

and suggest lactation mastitis grossly. Moreover, foci of lactation hypertrophy varying from fully developed acinar hypertrophy to small residual areas will differentiate lactation mastitis.

In traumatic fat necrosis, there is often a definite area of liquefaction and necrosis. Microscopically, there are many giant cells, often in sheets similar to those observed in plasma cell mastitis, but here the giant cells show ingested fat droplets and lipoid crystals. Amidst new fibrous tissue and surrounded by giant cells are seen "cigar-shaped" areas of cholesterol and groups of broken down fat cells. Large epithelial cells accompany the fat necrosis and may be mistaken for plasma cells which must also be differentiated from the numerous attendant phagocytic mononuclear cells.

One of Adair's cases was grossly considered tuberculosis in that it showed a wide area of skin infiltration, discoloration and irregularity suggesting an old healed sinus. Another case appeared tuberculous on cut section of the tumor. A third case, histologically, presented a cellular reaction with giant cells similar to the tubercle. If there is a draining sinus, it rules against plasma cell mastitis. However, in the absence of suppuration, these two processes may be indistinguishable even grossly. The histology of tuberculosis needs no illumination and the plasma cell exudate is usually sufficient to solve the problem. Yet swollen plasma cells and giant cells may be easily confused with a tuberculous granulation tissue.

Syphilis of the breast is rare. Adair in 1924 found only forty-five cases in all the literature. This very rarity probably accounts for its non-recognition. Its gross manifestations are protean, often simulating cancer, especially before central necrosis and sinus formation ensue. Microscopically, lymphocytic infiltration of the media and the perivascular concentration around adventitial vessels serve to distinguish syphilis of the breast.

The diagnosis of subacute and chronic mastitis of the simple forms is facilitated by the fact that it is more commonly bilateral and more extensive. The breast can be picked up as a whole, and has a saucer-like edge. The inflammatory reaction rarely shows more than an occasional plasma cell.

To the pathologist, the clinician can often give an illuminating story in plasma cell mastitis—that the onset is acute with moderate fever and presents a diffusely tender mass in a non-lactating breast covered by a reddened, hot, edematous skin and accompanied by enlarged tender axillary nodes. The progress is characteristic; it is one of slow but continuous regression, leaving a lump in the breast that is hard but not painful and neither increases nor decreases in size with time. Inflammatory carcinoma of the breast may closely resemble this picture in the early stages. However, subdermal lymphatic invasion by the cancer results in irregular thickening of the skin which is distinctive, and the growth is steadily progressive. Diffuse duct carcinoma, also, in the presence of superimposed inflammation, may simulate plasma cell mastitis but it likewise is steadily progressive.

No better termination of this discussion could be made than to quote the words of James Ewing from Adair's original article:

"From a survey of the present material it appears that we are applying the term plasma cell mastitis to a special group of cases which belong in the general class of chronic or subacute suppurative inflammation of the duct system of the breast. These cases differ from the ordinary suppurative mastitis in the absence of definite abscesses and generally in the wide extent of the process. The process is also less acute and the productive element much more pronounced than in suppurative mastitis. These facts indicate that bacterial infection plays a less prominent rôle and chemical irritation a more prominent rôle than in suppurative mastitis. In the particular group of cases which has attracted our

attention, the plasma cell infiltration is extremely abundant and widespread, producing rather bulky tumor masses which clinically resemble active carcinoma, and even under the microscope may be difficult to distinguish from cellular carcinoma.

"The main gross anatomic feature is the presence of many much thickened ducts which are filled with puriform material, and may extend over a large segment or nearly the whole of the breast. In most characteristic cases the cellular exudate is diffuse, making a broad opaque, sometimes yellowish tumor-like mass in which distended ducts are less obvious or not even visible. These are the cases which resemble carcinoma, but as a rule, there are small foci of puriform softening which are not found in carcinoma.

"The plasma cell exudate begins in the walls of the ducts and extends between the acini in adjoining lobules where the process becomes diffuse. Polymorphonuclear leucocytes are present in variable numbers, but are often very scanty. The phagocytosis of fat is a prominent feature and many of the cases show a great many large plasma cells engorged with fat and resembling xanthoma. These areas have a yellow color.

"Proliferation of the lining epithelium is a peculiar and prominent feature. The affected ducts are lined by from six to ten rows of large, somewhat hyperchromatic, epithelial cells which often raise the suspicion of carcinoma of the duct. Yet the later progress of these proliferating cells ends not in carcinoma but in generation fragmentation and formation of giant cells of all sizes. Many of the giant cells and degenerating epithelium produce structures which closely resemble tuberculosis. Usually the foreign body nature of these giant cells is obvious because they usually contain much fat. Stains for tubercle bacilli are negative, and guinea pig inoculations are also negative. The appearance of the proliferative epithelium in the early or milder stages of some cases strongly recalls the appearance of comedocarcinoma. In a few cases the proliferating epithelial cells produce many small hyperchromatic giant cells, a picture which again approaches that of large cell carcinoma."

As such the entity remained until C. W. Cutler, in 1934, reported a case of a tumor in the left breast of a 49 year old female who subsequently developed tumors, histologically identical with the breast tumor, in the larynx, the fascia over the sterno-clavicular joint, in the upper right border of the left breast and in the right antrum. The original breast tumor was called a plasma cell mastitis. The case was seen and discussed by Drs. Adair and Ewing. Dr. Adair considered it a metastasizing plasma cell mastitis. Dr. Ewing considered it a plasma cell tumor and was of the impression that plasma cell changes with tumor formation occurred chiefly in fatty areas such as the breast and bone marrow. If the original tumor was correctly diagnosed plasma cell mastitis, it is an entity capable of metastases; if this is not the case, there is a malignant neoplasm so closely resembling plasma cell mastitis in histopathology as to be markedly confusing.

CASE REPORT

C. S., a colored married female, 48 years of age, fell and struck her left breast one year prior to entry and one week before admission noted a lump there. Close questioning revealed the fact that the left breast had been hot and tender at the time of the first trauma.

The patient had had nine children and her menopause occurred two years before she entered the hospital. She was moderately obese, with pendulous breasts. Axillary nodes were palpable and there was skin fixation and nipple retraction of the breast.

A diagnosis of carcinoma was made and radical mastectomy done.

Pathology. Gross, the specimen included a left breast and pectoral muscles with axillary contents. There was nipple retraction, and grayish puriform material was expressed from the nipple. The tumor, 3 × 2 × 2 cm. in size, was just beneath the areola, fixed to the skin. It was irregular in outline and faded into the surrounding breast tissue with radiating bands of fibrous tissue. It cut with cartilaginous resistance and showed a homogeneous gray

surface. Radiating from this mass into the breast were dilated tortuous ducts filled with puriform material. No gross pathology of the axillary nodes was noted.

Very little normal breast tissue was present. The ducts and gland acini were markedly dilated and partially filled with bluish staining vacuolated albuminous secretions. Dilated ducts and acini were lined by a flattened cuboidal epithelium showing no evidence of proliferation. Other acini were much smaller and lined with a low columnar epithelium which showed evidence of proliferation in some instances. Some of the glands and ducts were lined by two or three rows of epithelium, some of which showed partial desquamation.

A large part of the biopsy specimen was made up of granulation tissue, characterized by numerous fibroblasts, newly formed blood vessels, multinucleated giant cells and an almost pure culture of plasma cells. The plasma cells were fairly large and swollen and showed a characteristic granular, faintly basophilic cytoplasm with an eccentric nucleus.

Other sections differed only in a greater abundance of mature connective tissue proliferation and localized lymphocytic infiltration. Often the sheets, cords, and foci of plasma cells were concentrated around dilated and hyperplastic ducts and acini.

Grossly the breast would be difficult to distinguish from carcinoma. The traumatic history brought in the possibility of traumatic fat necrosis, but the cut section of the tumor mass did not suggest this. The histology of the tissue immediately clarified the picture and eliminated confusion.

SUMMARY

A gross and microscopic study was made of plasma cell mastitis of the breast as presented in thirteen cases, including one here reported. Clinically this condition is often confused with cancer, but the history is characteristic. Although the gross features of the tumor are often equivocating, the histology is almost pathognomonic. It is characterized by an inflammatory granulation tissue which presents a preponderance, frequently almost a pure culture, of plasma cells. However, associated with dilated ducts and a desquamative epithelial hyperplasia, it may be confused with comedocarcinoma or its fibroblastic and giant cell formation may suggest tuberculosis. A recent case of multiple plasma cell tumors following an initial plasma cell mastitis of the breast suggests that the entity may be neoplastic after all. At least it should be considered precancerous and treated as such. The rarity of the disease is more apparent than actual, for many cases go unrecognized or unrecorded.

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REPORT OF A CASE OF MIXED TUMOR OF THE TONGUE

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M IXED tumors of the tongue have been clarified by the review of the ten cases in the literature by

viously. The patient's attention was called to the development of this tumor after an inlaid filling in the left first upper molar had dropped
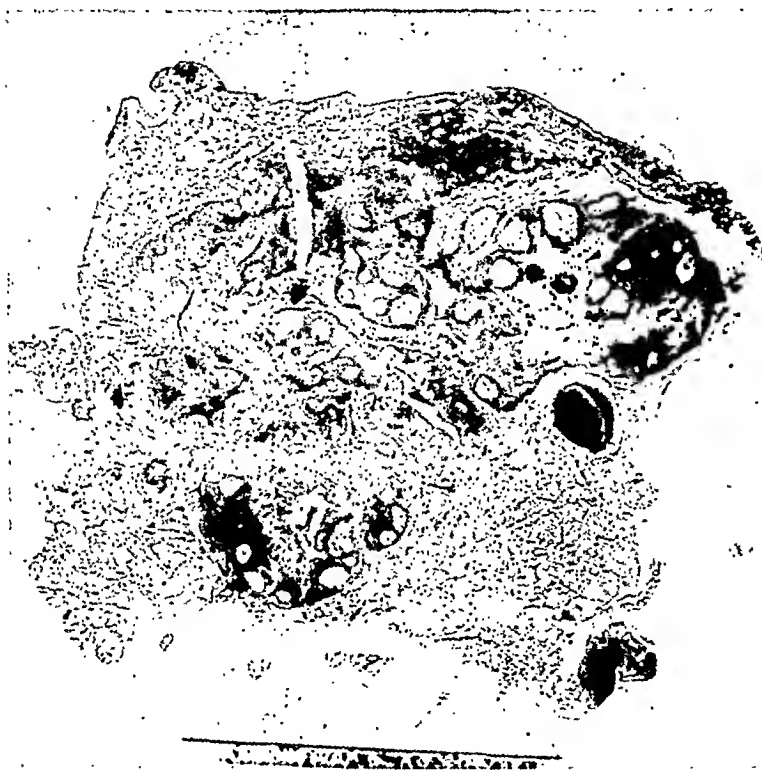
Fig. 1. Low power. Cross section of the entire tumor, showing epithelial elements (glands) in lower right corner; and, mesothelial structures (oval area of cartilage, follicles, and fibrous septa).

Brunschwig,[1] who established certain criteria for such tumors, namely—epithelial elements in any arrangement, and mesothelial structures as cartilage, muscular tissue, and fibrous connective tissue. We present the evidence in the following case as in favor of another instance of such very rare tumors of the tongue.

C. K., a dentist, was admitted to the Norwegian Hospital for removal of a small mass on the tongue which had appeared one year pre-

out. He later had it removed because of the considerable irritation to the tongue produced during chewing.

The tumor, on inspection, was white, round, hard and fibrous, the size of a pea, and was located on the anterolateral aspect of the left border of the tongue, 1 inch from the tip. It was embedded in the margin, involving the entire thickness of the tongue, and it remained constant in size after its appearance.

At operation under local anesthesia, a wedge-shaped piece of tongue was removed, the incisions extending well wide of the growth.
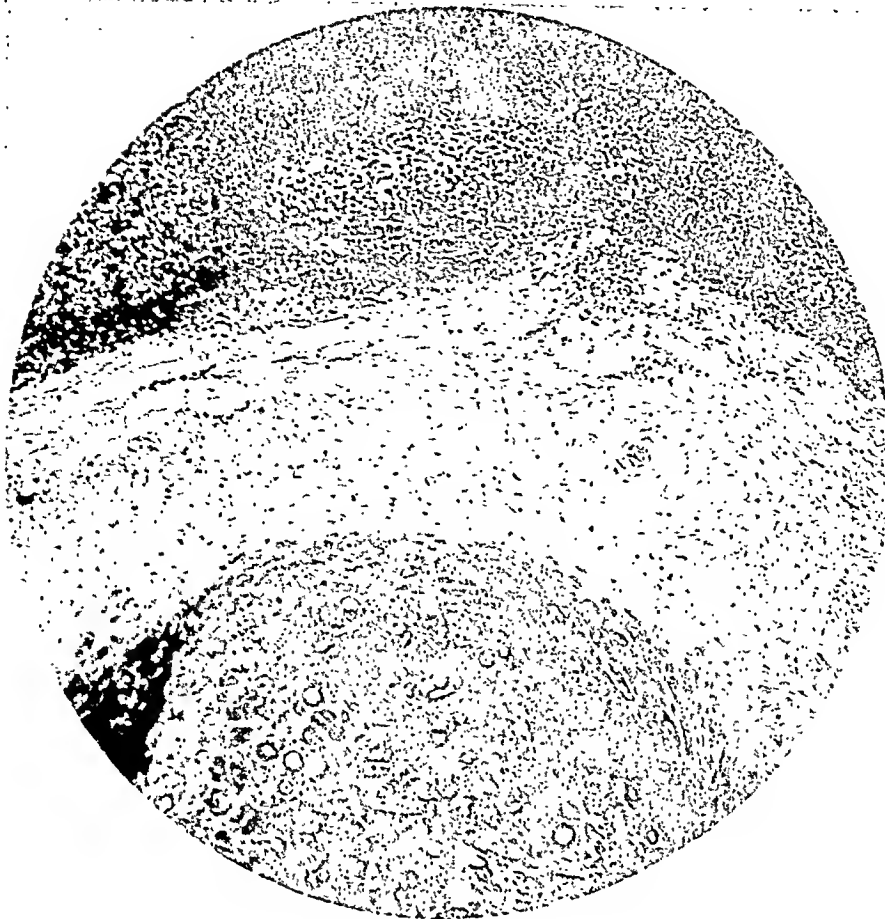
FIG. 2. Area of cartilage and lymphoid follicle with intervening fibrous septa.
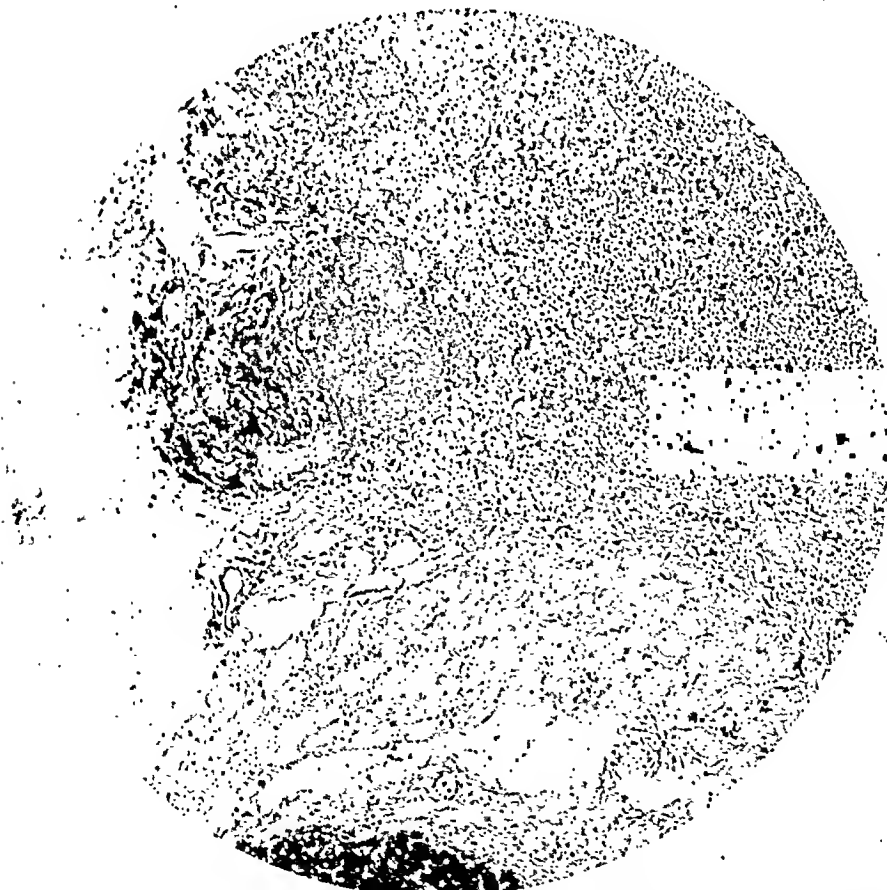
FIG. 3. Area of old hemorrhage and pigmentation bordering on muscle layer.

The microscopic picture showed a layer of flattened epithelium beneath which were several collections of hyperplastic lymphoid follicles separated by fibrous connective tissue. Beneath the lymphoid layer was a group of glandular acini, with an area of cartilage surrounded by fibrous tissue interposed between the two. In the deeper portions of the tumor appeared an area of hemorrhage and pigmentation.

A recent examination of the patient disclosed a scarring of the tongue at the site of operation and area of anesthesia the size of a quarter, with no evidence of local or regional metastasis.

DISCUSSION

Mixed tumors of the tongue are very rare, and as Wood[2] states, they resemble mixed tumors of the salivary glands. Apparently only a small proportion undergoes malignancy. They do not grow very rapidly and tend to produce regional metastasis only.

From the very nature of the growth, such tumors are expected to vary widely in their histologic architecture. All the structures enumerated may be found normally in the tongue. The question arises as to whether this tumor represents a simple hyperplasia of the lymphoid elements with a concomitant fibrosis, located in proximity to an area of cartilage and a collection of mucous glands; or, possessing the two essential characteristics described by Brunschwig, it is a mixed tumor.

SUMMARY

1. Mixed tumors of the tongue are diagnozed on certain criteria established by Brunschwig.

2. The histologic structure found in mixed tumors of the tongue may vary widely, but the essential characteristics will determine the nature of the growth.

3. Tumors of the tongue should be closely scrutinized, as in many cases divergence of opinion will exist as to whether the pathology be one of mere hyperplasia of normally found tissues or real tumor formation.

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PENETRATING KNIFE WOUND OF THE SKULL WITH SUBCORTICAL HEMORRHAGE

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A COLORED man, F. H., aged 28 years, was struck in the occipital region with a clasp knife during a street brawl.

The depth of the blade, as indicated by the x-ray (Fig. 2), was somewhat misleading due to the angle of the film. (Fig. 3.) The dura had been

FIG. 1. Pocket knife which has penetrated the skull.
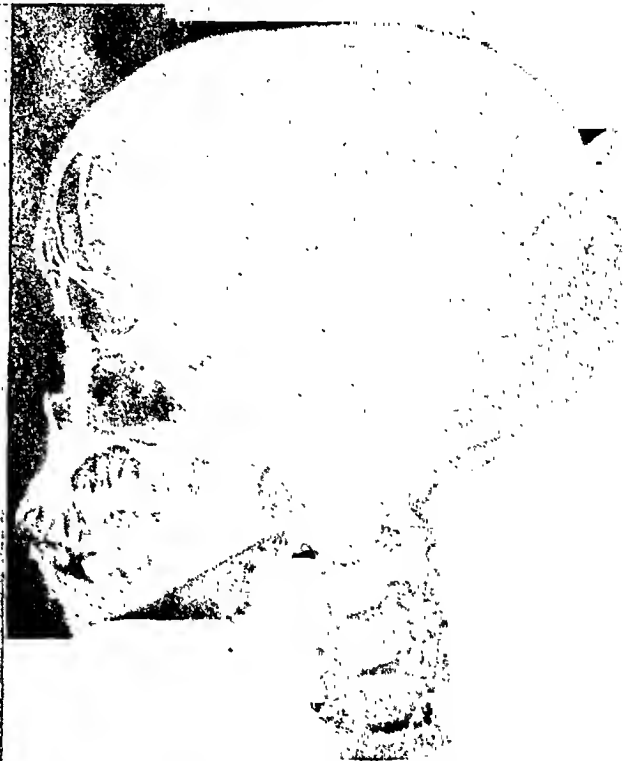
FIG. 2. X-ray film showing penetration of knife blade within the brain substance.

He was rendered semi-conscious for a few minutes. He regained consciousness and was transferred to an emergency hospital, and thence to a private hospital.

Complete physical and neurologic examination carried on two hours after injury was entirely negative, except for a slight drowsiness, local pain, and the protruding knife blade. (Fig. 1.) The handle was disengaged from the blade. The patient was given tetanus antitoxin, and immediately transferred to surgery.

A semicircular incision was made in the scalp with a central linear incision. The scalp was stripped away and the knife was extracted through the central incision. A perforator and burr opening was made in the skull, and a small fragment of bone was cut around the knife blade.

perforated and was under increased tension. The dura was opened wide, and palpation of the brain indicated a soft area underlying the knife perforation. The cortical vessels on both sides of this wound were clipped and the cortex incised. Directly beneath the cortex and extending down for an inch and a half could be seen a large clot, which was evacuated. It contained about an ounce of blood. At the base of this cavity could be seen a large vessel which was bleeding rather profusely. Silver clips were applied to both sides of the vessel and the cavity was washed with saline. The dura was tightly closed and a few small fragments of bone were placed over it. The scalp was then closed with layers of silk and a silver foil dressing applied.

The patient left the hospital in two weeks and rested at home for an additional three weeks. At no time did he have any complaints

FIG. 3. Resection of skull with removal of knife blade.

and no complications whatsoever occurred. Figure 4 shows the patient three months later, completely recovered.

This case offers some interesting points; the penetration of the skull by a knife thrust; the very short period of semi-consciousness, with

FIG. 4. Two months later, patient entirely recovered. No sequelae.

no complete unconsciousness; and further, the importance of looking into the brain following a penetrating wound of this type. Had the knife been withdrawn, the patient without doubt would have developed a severe hemorrhage which might have proved fatal before the skull could have been opened.

TORSION OF SPERMATIC CORD

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IN discussing torsion of spermatic cord and testis, nearly all writers stress the sudden, increasingly severe and continuous pain. They give the impression that the condition is a progressive one, ultimately going on to strangulation of the cord and gangrene of the testis. This, however, is not always so.

I operated in a case of torsion of a spermatic cord and testis in which the symptoms differed from those usually described, in that attacks of only moderately severe pain occurred at infrequent intervals for a period of more than a year before operation.

CASE REPORT

F. B., aged 14, white, male, is one of a pair of twins. However, while his twin brother has developed normally, the patient has remained markedly retarded both physically and mentally; his condition has been diagnosed as cretinism.

For more than a year before I first saw the boy on September 4, 1936, he had complained intermittently of moderately severe pain and tenderness in the left inguinal region. This pain was short in duration, usually lasting no more than two or three hours, but it was severe enough to make him cry. He had been examined by several physicians who reported that they could feel a small exquisitely tender mass in the left inguinal canal. Between attacks the pain disappeared, but the mass was always present.

When I first saw the patient he was complaining of moderately severe pain in the left inguinal region. Examination showed the penis undersized, the scrotum rudimentary, the right testis small and in the scrotum. A small, tender testis could be felt within the left inguinal canal. My diagnosis was torsion of the left spermatic cord and testis, and I accordingly advised operation. The parents preferred to defer operation, hoping that the boy would recover from this attack as he had from former attacks, and asked to have him watched for a few days. The pain and tenderness continued and after three days the parents consented to operation.

Under avertin anesthesia a typical Bassini incision was made. When the inguinal canal was opened the spermatic cord and testis were found to be swollen, dark blue and boggy. The cord had undergone two complete torsions in a clockwise direction. The necrotic testis and cord were removed, and the small, indirect inguinal hernia repaired. The patient's convalescence was uneventful. Six weeks after operation the wound was well healed and the child had no complaints.

SUMMARY

Because most writers on the subject of torsion of spermatic cord have stressed the severely acute, continuous and progressive nature of the symptoms, I feel that this case with somewhat different symptoms should be reported. The symptoms were moderately acute rather than severely acute, and they occurred at intervals for more than a year, rather than continuously. It seems probable that during this time the spermatic cord had undergone partial torsion and release several times.

A SIMPLIFIED METHOD FOR MAKING MOULDED SPLINTS

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THE method to be described is one that is recommended for making moulded plaster of Paris splints and for splints measuring from 10 to 36 inches are drilled. The holes are numbered for the proper distances. The pins are placed
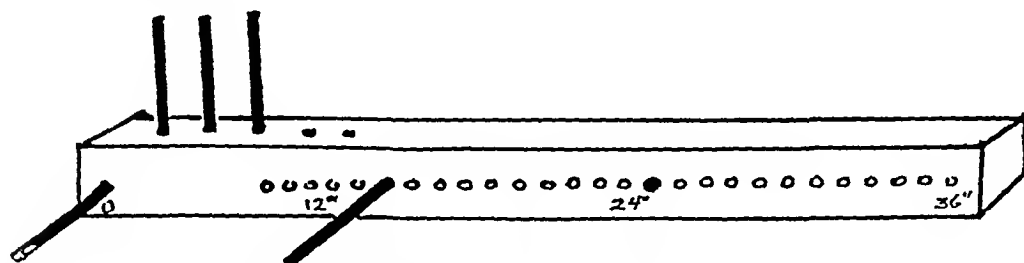
Fig. 1. Wooden bar mounted on wall with pins placed for making a splint 14 inches long. Spare pins are on top of the bar. Shelf for catching plaster drippings is not shown.

reinforcements rapidly and neatly. This method is useful both in the hospital and in the office. An assistant is not needed to keep the ends of the plaster bandage lined up properly. Once the surgeon has measured the extremity to determine the length of the desired splint, the plaster is rolled to exactly that length without the necessity of trimming off any excess. The splint comes off the rack smoothly and evenly formed.

The apparatus consists of a piece of 2 × 4 lumber about 40 inches long, which is fastened to the wall of the plaster room either horizontally or vertically, as space will allow. The vertical mounting will take up very little wall space. This wooden bar has holes three-eighths of an inch wide and 1 inch deep, drilled at intervals of 1 inch. (Fig. 1.) Into these holes are inserted two wooden pins, each three-eighths inch thick and about 8 inches long. Inasmuch as moulded splints are rarely less than 10 inches in length, the first nine holes are omitted, and only the holes

in the holes which correspond to the length of the required plaster splint.

It is suggested that some holes be drilled into the top of the wooden bar so that the two pins (and extra ones) may be stored when not in use. This will avoid their being broken off by passersby. It is also suggested that a shelf about 10 inches wide and about 4 feet long be built beneath the apparatus to catch the dripping plaster and thus avoid messing walls and floor and aid in keeping the room clean. This shelf may be mounted on hinges so that it can be folded out of the way when not in use. For the vertical mounting, the shelf need be only one foot square.

When the desired length for the molded splint is ascertained with a tape measure, the pins are inserted at the proper distance and the operator starts rolling the plaster bandage over them. (Fig. 2.) The plaster may be rolled while dry and subsequently immersed in water for the softening process. This will avoid splashing of plaster. When the required thickness is obtained,

the pins are removed and the moulded splint is slipped off and applied either directly on the limb, or placed on lint or too much wall space in the plaster room. For ordinary use the 40 inch wooden bar will be sufficient.
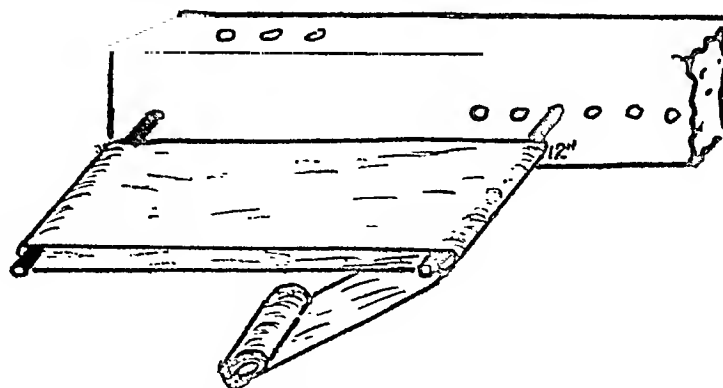
Fig. 2. Formation of splint by rolling plaster over pins.

padding prior to application to the fractured extremity.

The apparatus will be found useful in cutting dry rolls of plaster into strips of suitable length which may be stored and used as occasions arise. As many lengths of accurately cut plaster strips as necessary may be used.

Should splints longer than 36 inches be needed, as for example one 48 inches long, one may mould a splint half this length and cut it across at only one end before removal from the pins. This avoids having an apparatus of excessive length taking up

The apparatus will cut the cost of plaster, for the ease with which splints are rolled will permit closer application of succeeding layers and will give the splint greater strength. It will be found that two rolls will do for a given splint where three were formerly required; also, there will be less waste since we may avoid constructing excessively long splints which require subsequent trimming.

The cost of the entire apparatus should not be more than twenty-five cents, as it may be made from scrap lumber.
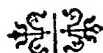
A NEW SELF-RETAINING ANOSCOPE

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THERE are many types and varieties of anoscopes now in use, each possessing features which are preferred

The self-retaining anoscope here presented has no original features, but is an adaptation of the best features from the
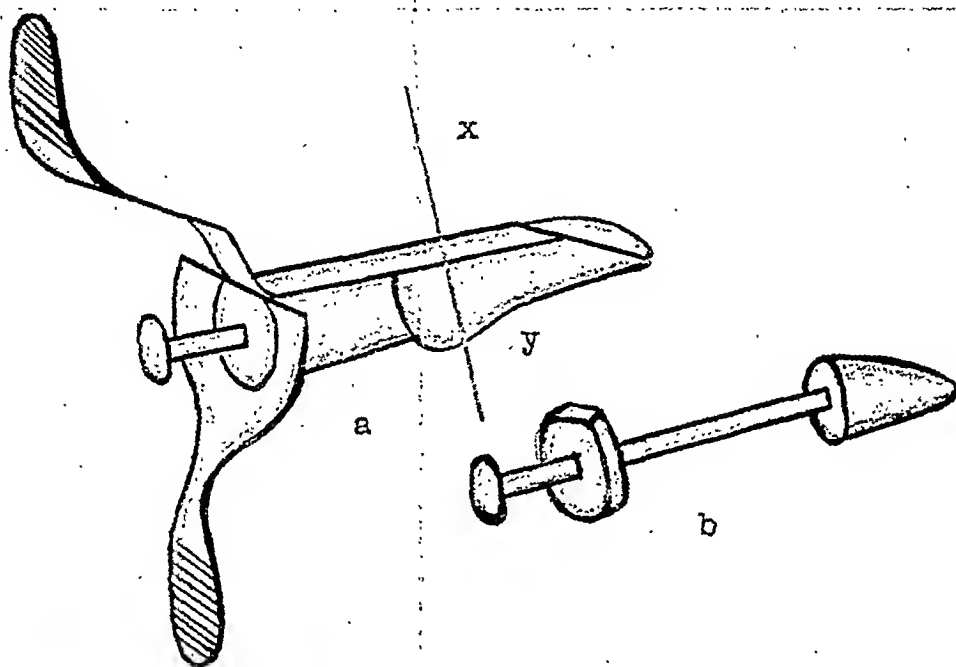
FIG. 1. Self-retaining anoscope. a, instrument with the obturator in place. b, obturator alone.

by some physicians and rejected by others. The number of types available proves that we still do not possess an ideal instrument which would supplant all others and could be used both in examination and in treatment of the anal canal.

The most satisfactory anoscopes now in use are of the tubular or conical variety with a slide (fenestrated), or with an oblique opening. Unfortunately these instruments are not self-retaining. The physician working without any assistance is obliged to retain the anoscope with one hand, while the other must perform all other manipulations. The end of this inconvenience would certainly be highly appreciated, even by those who have ample assistance.

most widely used apparatus with an added device which makes it self-retaining. This instrument can be used in the examination of the anal canal without an anesthetic.

Many leading proctologists are now using the Smith self-retaining operating anoscope, an excellent instrument of the "bivalve speculum" type. However, it cannot be used unless the anus is completely anesthetized; without an anesthetic, it becomes an instrument of torture.

The present anoscope is based on the instruments devised by Martin, Hirschman, Goldbacher and Gant. From Martin's and Goldbacher's anoscopes it features the fenestration when the slide is withdrawn, and from Hirschman's the oblique open-

ing. The self-retaining device also is not new as it was used by Gant.

The slide permits the inspection of the walls of the anal canal, injection of hemorrhoids, applications to the mucosa, operative or other treatment for fissures, fistulas, crypts, etc. The oblique opening, considered by many proctologists of distinct advantage over the fenestrated type for the injection of internal hemorrhoids, may be used when preferred. The slide may be withdrawn or not, depending on the type of ailment to be treated and the preference of the physician in the particular instance. The advantages of the self-retaining feature are obvious.

The anoscope consists of a conical tube $3\frac{1}{2}$ inches long. The diameter of the proximal end is 1 inch, the distal $\frac{3}{4}$ inch. The distal end is oblique, making the section an ellipse and the shorter test element of the cone $1\frac{1}{4}$ inches shorter than the longer one. The proximal end is fitted with a flange. At a distance of $1\frac{1}{4}$ inches from the proximal end, there is a conical dilatation the base of which is $1\frac{1}{8}$ inches in diameter. This dilatation is gradually diminishing towards the distal end to fuse with the original cone at a distance of 1 inch from its origin. The slide runs through the entire length of the tube at its shortest element for $2\frac{1}{4}$ inches and is $\frac{5}{8}$ inch wide. The slide opens together with a part of the flange at the proximal end, leaving a part of the anal margin unobstructed. The conical dilatation of the tube, which makes the anoscope self-retaining, does not involve the slide. The obturator has a slanting end which facilitates the introduction of the instrument

and snugly fits its distal end. The instrument has two handles, one for the slide and the other for the main part, to facilitate its manipulations. (Fig. 1.)

Fig. 2. Section of the anoscope through the dilatation of the self-retaining device (line x-y of Figure 1).

CONCLUSION

A new self-retaining anoscope is presented. It has certain advantages over the ones in use as it combines the features of the fenestrated anoscope with the oblique distal opening and is self-retaining.

It can be used in examination of the anal canal without an anesthetic and renders treatment easier by being used according to requirements as a fenestrated or a nonfenestrated anoscope.

It is easily introduced, does not slide out when patient strains or coughs, can be rotated (advisable only when slide is in place), and is easily withdrawn.

This instrument will hardly replace the ones now in use. However, it renders work in proctology easier and provides an instrument with somewhat wider utility.

A METHOD OF MINIMIZING TRACTION TRAUMA IN RECTAL SURGERY

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WHAT the compass is to the sailor, landmarks are to the surgeon. As a result of the recent rebirth of inter-

FIG. 1. Resectoscope ready for insertion. Note that handles are wide apart to keep the instrument closed.

est in regard to the anatomy of the ano-rectum brought about by Hiller,[1] Milligan and Morgan,[2] Edward Levy,[3] and others, the importance of landmarks is realized for the first time by the rectal surgeon. The purpose of this article is to describe a method of surgical treatment which utilizes the landmarks of the anal canal as guides and, at the same time, minimizes the trauma due to the operation itself, that is, "traction trauma."

That the sphincter is divided by, and that muscle-spaces are formed by fascial extensions from the levator ani and the external coat of the bowel is generally known. Also, the fact is appreciated that certain components of the levator ani have a physiologic role in regard to sphincteric control. What is not generally known is that the landmarks within the canal furnish the key for surgical entrance into the surrounding muscles and spaces for the purpose of creating rest and drainage. Recognition of the dentate line, inter-muscular septum, and the puborectalis muscle is a necessary prelude for accurate surgical treatment of such anal infections as fistulae, abscess, hemorrhoids, fissure, and cryptitis.

Aside from the cases of severe rectal pathology in which all tissue is distorted, the surgeon may usually be guided by landmarks. In advanced cases of rectal pathology with atonic sphincters, pro-lapsed membranes, and tissue distortion from chronic inflammation, the problem of the rectal surgeon becomes difficult indeed. "In these cases," says one eminent proctologist "the judgment of Solomon scarcely suffices to tell how much tissue to remove and how much to leave."[4]

In most rectal operations, however, landmarks are deliberately destroyed. Here, where the sphincter is extensively dilated or divulsed, and the mucous membrane is

drawn down and everted from the anal canal, we have immediate and remote difficulties for both patient and surgeon.

cylinders of tempered steel—the inner being encompassed by the outer one—and an obturator. After inserting the instru-
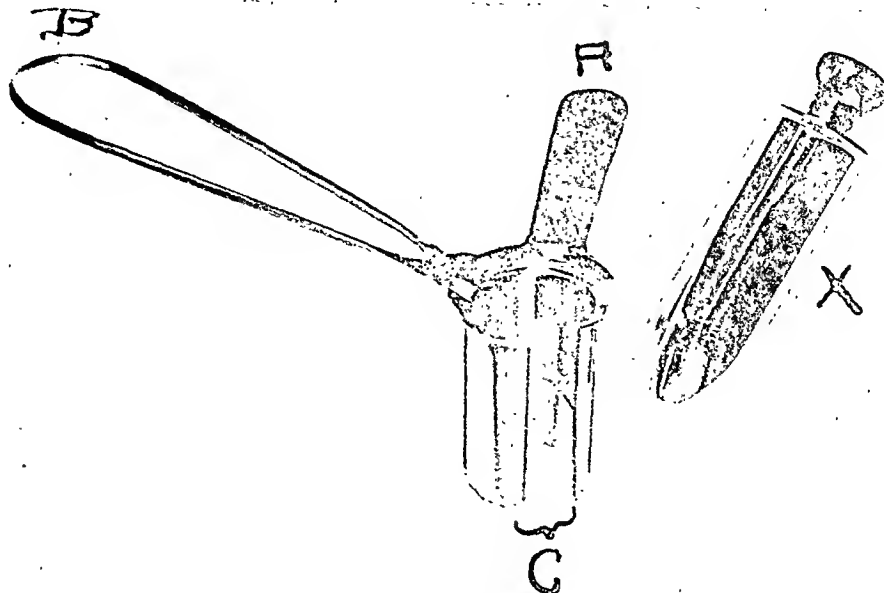
FIG. 2. After insertion, obturator, x, is removed. Handle A, which is attached to the inner hemicylinder, is rotated toward handle B, which is attached to the outer hemicylinder. Thereby a corresponding opening is secured at C.

This "traumatic traction" causes damage. The muscle fibers of the sphincter are broken. The blood vessels and nerves of the hemorrhoidal plexus are ruptured. Portions of the mucous membrane are avulsed from the bowel wall. There is an extravasation of blood into the perianal tissues with ensuing tissue distortion. Here, again, we are unable to judge how much tissue to remove. The remote difficulty is for the patient in the form of increased postoperative pain and disability—and often a poor result.

Traumatic traction may be minimized by applying the surgical procedure within the anal canal.[5] The necessity for strenuous dilatation of the sphincter and avulsion of the mucous membrane is thus avoided. An instrument that will provide adequate exposure of the anal canal for routine surgical procedures without producing trauma will remove the immediate and remote difficulties to which we have referred.

Such an instrument is shown in Figure 1. It is termed a resectoscope for the reason that it is a surgical instrument, in contrast to the anoscope which is for the purpose of examination. It is composed of two hemi-

ment (as an ordinary anoscope) and withdrawing the obturator, an arc of the anal canal may be exposed from 0 to 190 degrees

FIG. 3. Resectoscope inserted. Patient is in prone semi-inverted position. Hemorrhoid in left anterior quadrant is being ligated.

by rotating the handles which are attached to the hemicyclinders. This feature of adjustability is of great advantage for it allows the pathologic tissue to prolapse into the opening which can be adapted to

receive it. At the same time, adjacent tissues are withheld from the operating field.

That there is sufficient exposure afforded

FIG. 4. Excision of hemorrhoid following ligation.

by this instrument for the adequate surgical treatment of ordinary anorectal pathology is attested by an abundance of clinical experience. By its use anal infections are effectively treated. For example, the demarcative line between normal membrane and hemorrhoidal tissue may be clearly visualized when performing hemorrhoidectomy. The incisions for removal of a chronic anal ulcer may be made with precision through the space exposed. Crypt openings at the dentate line are accessible for the passing of a probe in cases of "blind" or complete fistulae. Crypts and papillae are easily removed.

Although the technical difficulties are increased to a certain extent by this

method there can be no doubt that the advantages to be derived compensate adequately. The necessity for acquiring a

FIG. 5. Closure of wound margins after excision of hemorrhoid.

slightly increased dexterity of surgical technique will be amply rewarded by the increased welfare of the patient.

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[From Fernelius' Universa Medicina, Geneva, 1679.]

BOOKSHELF BROWSING

INCUNABULA MEDICA*

THE YEAR 1000 A.D.

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WHERE to begin in a chronicle of the medicine of the early centuries is perplexing. Each century since the dawn of the Christian Era furnished one or more personalities who stood out head and shoulders above their contemporary confrères. Generally this prominence had been attained because of unusual intellectual capacity as exemplified by the origination of an idea or theory, then the elaboration of such an idea into something of practical use in the treatment of the sick. When such was not the case we find men attaining prominence because of unusual technical skill in some surgical procedure.

As an illustration, there were the endocrinologists of the times, who fed fresh gonadal tissue to their patients for relief of impotence, the internists who took their anemics and tuberculous directly to the site of slaughter of oxen and forced them to eat of the fresh raw liver and to drink of the warm fresh blood of the animal.

Theirs was not to reason as to the why or the wherefore, nor to elaborate involved and usually conflicting hypotheses as to what took place. They only knew that something happened to a certain percentage of their patients after such therapy. They were better, they felt better, they looked and acted better. What more could the medical man ask for than therapeutic confirmation of what he was using?

From the surgical aspect we find the practitioners of these times paying strict attention to the preparation of suture material, soaking this in strong wine and spirits over a long period of time for antisepsis and being particularly proud in their perfect approximation of wound edges in order to produce suture lines which were scarcely visible when healed. As to personalities, one finds that a Paulus, Bishop of Merida, performed cesarean section, not once but many times during the middle of the sixth century and history corroborates that his mortality was low.

In the seventh century, an accurate and most adequate description of a carbuncle of the neck is found, stressing the multiple chambers and recesses characteristic of such a condition and advocating long, deep, and extensive crucial incision as appropriate therapy.

* This is the first of a series of papers which will present descriptions of medicine and its leading exponents in the Middle Ages.

In the tenth century, a female physician, Trotula of Ruggieri, was summoned in consultation all over Europe to perform the operation of perineorrhaphy.

Roger of Salerno and his pupil, Roland of Parma, flourished during the eleventh century, the former noted as the greatest surgeon of his day, who unhesitatingly performed trephining of the skull in cases of injury or fracture producing pressure.

To him also we are indebted for the first description of contrecoup fractures, and many were his difficulties in putting across the idea that a blow could be on one side of the head and the actual fracture on the opposite. The skeptics of the time were hard to convince.

In the same century, we find one Gariopontus describing lung abscess as follows: "A painful molar tooth being extracted by an inexperienced physician, a friend of mine, a philosopher, was done to death, because the marrow of the tooth when extracted, along with the surrounding pustulous matter, ran down into the lungs, causing a fetid and putrid process of such a stench that none could remain in the same house with him."

We find these physicians using an infusion of mandragora and opium as an anesthetic to produce a deadening intoxication, also the vapor from a distillation of hemp seed.

One could go on and on indefinitely citing such examples of effort and endeavor. Arbitrarily the year 1000 A.D. has been chosen from which to make a start in the story of the Incunabula Medica.

The year 1000 A.D. represents almost a definite line of cleavage in the story of the progressive march of medicine. Medicine first began to assume more practical aspects at this time. These steps in progressive medical change will be described as the story of the events leading up to them is unfolded.

Perhaps first it is best that a definition of the term "incunabula" be given, that what follows may the more easily be understood. This term means literally "cradle books," the very beginnings of books, the foundation stones, and is taken to include all books published from the year 1456 when printing was discovered to the year 1500 inclusive.

An impressive number of the books published during this period pertained to medicine, and it is these that we shall be interested in.

Prior to the year 1456 all available medical literature existed only in manuscript form. These manuscripts were the work of scribes, each trying to outdo the other in perfection. Some of the illumination is so perfect in its sheer beauty that it is almost beyond belief that it could have been done by a human hand. The perfection of line is evident in almost every single manuscript. It was rare, however, for any manuscript to exist in any one place in its complete form. Because they were so sparse and therefore available to only a few, they were divided into parts, in order that more individuals might have access to their use. The surgical manuscript of Roger of Salerno, as an example, existed only in parts—Part i, devoted to the surgery of the head; Part ii, to the surgery of blood vessels, particularly veins and outlining the operation of phlebotomy; Part iii, examination of the urine, and so on.

Thus it became the province of the earliest typographers to gather together many parts of a manuscript in order that they might print as complete an opus as possible. It is because of losses through fire, confiscation, and such, that many of the early printed incunabula have such gaps in their content. For multiple reasons the typographer could not locate the missing parts or obtain access to them.

There had been many famous and great doctors prior to the beginning of this eleventh century. These doctors were usually members of various religious orders, the Franciscan, Benedictin or Dominican, and the medicine and religion of the time were closely interwoven. Very little is known with regard to the lives and medical

contributions of many of these doctors. How much they may have contributed of value, which was subsequently lost to posterity, is intriguing to speculate upon.

Here and there had existed individuals about whom history has recorded little, but who seemed each to represent a sort of fountainhead of knowledge and to whom a few pupils would come to study. These pupils would then migrate and spread out into other parts of the world, carrying with them the teachings of their master. Many were of sufficient intellectual capacity as to be able to acquire more knowledge through their own deep reasoning and by their own diligent study. These pupils in their turn would often become masters and great teachers, with the result that a wide dispersion of their own knowledge took place through their successive pupils or students.

The association of medicine and religion had always existed from earliest tribal times where the "healer" of the tribe was the most important and presumably the wisest individual. Jesus Christ himself was a practitioner of medicine when he performed the miracles of healing in association with preaching of religion to the multitudes. The association of religion and healing is today still exemplified in varying forms of worship all over the world.

A possible reason for the meagerness of our knowledge of ancient literature and of ancient science, as well as of the early contributions made during the first ten centuries of the Christian era, can be laid to the attitude of varying religious groups, more particularly of the Catholic Church itself, as it then existed. Much has been written refuting this, but impartial and unemotional reading and study cannot help but substantiate such a conclusion.

The rule and the custom of the year 1000 were that ancient civilizations should be forgotten and obliterated, except for such meager fragments as might be adapted to some selfish purpose. Everything of literature and science considered as non-conforming was to perish—one of the many

examples in history, of the sadistic tinge of the Church, which in theory preached against the individual practice of that very thing. The extremely fortunate few who managed to acquire any degree of education or knowledge were taught to scorn that knowledge which had come before them and to lay emphasis entirely upon that which was of the present and to come. Only this could be good for the mind and best for the soul. Lest you become too ardent a believer that human biology has changed for the better, is not contemporary thinking and teaching much along this same order? Emotionalistic interpretation of all things without regard to the lessons of experience written down in history is most assuredly the order of our own day.

It was about the year 1000 A.D. that nursing as a practical working institution first came into being. There had always been the nursing of a member of a family, of a friend, even of an individual in distress, by someone else, but organized nursing by a group actually instructed in the practice, took place first at about this time.

The establishment of the first monastic order took place about 300 A.D., but the actual flowering and growth of such orders began to make definite headway about seven hundred years later. The year 1000, therefore, represents a rather definite time spot from which to make a beginning in a story of early medicine.

These various religious orders, both male and female, took over, as one of their first functions, the care of the sick of a community. Theretofore the care of the sick had been haphazard, taken care of mainly by small groups of volunteer workers, usually men and women who attached themselves to some lordly bishop's retinue and existed much as hangers on. They were assured rather precariously of just sufficient to keep body and soul together, although it was mainly the soul that was taken care of. The body depended upon scraps from the tables of the higher

ups or upon whatever foraging into the surrounding countryside could produce. It was in these times that such assin-

there was a reward. Most definitely so. All who died in such manner, openly and publicly professing their humility, upon

lis digestionis. Mundificatio spirituum fit cum cordi. alibus predictis. Infrigidatio febris fit per modum pre dictum in cura et per cibos refrigeratos. Primus cibus est ꝙ coquatur pulla vl' pullus plenus acetosꝰ agresta et portulaca cum croco et detur brodium ꞇ fiat colaticum. Secundo detur ordeatum ꞇ auenatum cum lacte amigdalorum, ꞇ de pulla potest comedere extremitates cum suco limonis citranguli vel agresta. Tercio dentur parue aues bullite vel toste cum acetosa. Et confortetur aliquando cum bonis cibis: licet aliqualiter sint cōtrariȷ et virtus confortetur. Nam multi illorum qui agunt viriliter super illud id est supra restaurationem casus appetiꞅ et comedunt violenter absoluuntur ꞇ viuunt, verba sunt Auicen. quarto cano, cap. proprio. Dentur poma pira ꞇ citonia cocta sub prunis, ꞇ similia. Possunt dari pedes mutonis cum aceto. Si vinum detur sit clarum subtile odoriferum cum multa aqua fontiua ad hoc vt per ipsm restauretur appetitus. Dicit magister Bernardus, ꝙ si epidimiati in vna die scilicet prima possint sustinere fleꝰ botomiam ꞇ distere ꞇ sudorem: euadunt. Machinentur ergo cibi diuersi in quibus aliqualiter infirmus delectet vt ipse sit tante obedientie ꝙ vi vel gratis sumat de illis. et cibi eorum semper tendant ad acetositatem ꞇc. Ille fabricator planetarum ꞇ constellationum et influentiarum, et qui ventis et mari imperat et cui omnia obediūt absꝗ mora conseruet nos a malicia aeris ꞇ influentie: vt post longa tempora bono fine vitam terminemus.

Tractatulus de epidimia ꞇ peste excellentissimi artiū et medicine doctoris Valasti de Tarenta impressus in imperiali opido Hagennaw per Henricū Gran Ano natiuitate domini necnon salutꞅ nostre Millesimo quaterꝗ centesimo nonagesimoseptimo feria ꝗnta ante festum sancte Katherine finiuit feliciter.

FIG. 1. Photostatic copy of a page from a thirteenth century manuscript of Valascus de Tarenta, physician to Charles VI of France. In his manuscript he advocates treatment of external cancers by means of an escharotic arsenical paste.

inities of human conduct took place as the kissing of the unwashed feet of beggars as a token of humility. Communal dividing of ill luck as well as good, gave birth to the idea of lying down beside a leper to share his burdens, and to the kissing of those afflicted with the plague. These practices are only a few examples of the means whereby numbers of people unwittingly went to their God, but in the belief that

dying became angels. Could one possibly ask any greater reward?

Among the first religious orders founded, the Benedictins, for no particular or valid reason, were much interested in medicine and had acquired and collected a substantial number of ancient manuscripts pertaining to medicine. They had then delegated those members of their order best qualified to the task of translating

these manuscripts and others to the task of studying and interpreting them in a manner satisfactory to the religious philos-

had renounced everything worldly in order to gain the peace of soul and mind which comes from solitary communion with one-

Fig. 2. A page from a manuscript of Roger of Salerno, outstanding surgeon of his time. His description of head injuries, trephining operations on the skull, and the contrecoup fracture could be improved upon but little even in this day.

ophy of the order. From this group of translators and searchers there arose a certain number of men who possessed a little above the average as to knowledge. They learned what to do in certain types of illness or injury as laid down in the rules for medical procedure found in the manuscripts of the ancients. These monks probably represented the first actual practice of medicine by an organized group, or one could say by a school of learning with a definite curriculum of study.

To the casual reader, the word "monk," of itself, is apt to convey a quick impression of a very learned scholastic gentleman who

self and God and knowledge. This picture is rather far from the actual and less vivid one.

The monk was, after all, a human being, of flesh and blood like all others, subject to the same instincts and emotions and biological urges. History records that many of them were rogues of the highest order. More often than not he was a very ignorant individual, but as time meant absolutely nothing to him, he often allotted his full lifetime to deciphering, translating, writing and illuminating one single solitary manuscript. He sometimes learned something during this labor, or at least he should have.

But more often he was actually entirely ignorant of what he was doing. He could translate words singly but not a group of words into an idea as a whole.

Let us assume, for the moment, that being human, he had a splitting headache or a bad case of indigestion or, more materially, a hangover from too much wine the evening before. From the historical accounts of the mode and manner of living of monks, and from paintings of the era, handed down to later generations, it is rational to deduce that many of them were gluttonous in their habits, and therefore prone to cirrhosis of the liver and gallbladder dysfunctions and the symptoms produced by these disorders. It is possible that they would be more prone to hand down pessimistic or melancholic interpretations of difficult lines than would other individuals with clear heads and normal digestions. Voltaire and Napoleon expressed trite opinions as to the head work of men under different states of digestive function. On what flimsy pedestals may the pillars of knowledge lie? How much could such a monk conveniently have forgotten or omitted in his translation because he didn't feel like working that day, or how many remedies for headache and indigestion did he leave out intentionally because he had tried them in his own individual case and they had not worked? In other words, how much did human foibles and weaknesses influence the actual amount of knowledge handed down to posterity out of these early repositories of knowledge? How much was lost or misplaced?

That the monk, however, could be very materialistic is amply demonstrated.

When he completed his labor he often signed at the end, "Deo Gratias"— "Thank God," but then the spiritualistic and the materialistic parts of his personality split, and one rose to the surface, for he sometimes added as a sort of postscript, "For this my labor, O God! of thy goodness bestow upon me many hats and caps, cloaks and coats, she goats and he goats,

sheep and cattle, and a handsome wife without children." So, after all, he was rather a practical fellow.

The idea of taking a sick individual from his house to a separate place of abode for the treatment of disease first arose at about this time, also as the result of the pilgrimage of the Crusades. En route to Jerusalem, of the thousands of pilgrims many became ill on the way, and, of necessity, a place had to be found to take care of them.

The survival of just such a custom from olden time to present day is best illustrated in our rural inaccessible districts, where many a physician takes his severe cases into his own home for better and more constant attendance and care.

During and after the Crusades, for one reason or another, leprosy became quite widely disseminated throughout Western Europe, and a need arose for some sort of asylum in which to segregate people afflicted with the disease. They could not indefinitely continue to live like dogs outside city gates, existing solely on the meager crumbs they could obtain by begging. Begging in itself was difficult and unproductive of results, since most people fled whenever a beggar approached who in the distance appeared to be a possible leper. It has been estimated that during the Middle Ages over 19,000 of these asylums for segregation, called leprosariums, existed in Europe and Africa. They constitute one of our first examples of public health and preventive medicine. Some have survived the toll of time and exist into the present day as true hospitals. The Allgemeines Krankenhaus in Vienna is an example of this.

From the sixth to about the eleventh centuries there had existed some so-called "regular physicians." These were laymen and did not belong to any of the religious orders. The main qualifications of these gentlemen were that they were skilled in uroscopy, the latter consisting mainly of squinting very long and learnedly at a flask of urine, noting its color, the amount,

and then tasting it, detecting acidity, sweetness and such. That represented more or less the sum total of the science and art of uroscopy.

A second qualification was that they must be able to read. Reading was considered an "art" and if one could merely read, regardless of how little, he was classified as a "scholar." This ability to read, however, was a very important turning point in the history of medicine. The very wealthy who had access to manuscripts and collections of writing contained in their libraries were too indifferent or too lazy or too taken up with their own importance, to bother to learn the art of reading. Then, as today, the ownership of a large library was an essential step in demonstrating one's wealth in goods, and helped classify an ignoramus as a patron of literature. The poor who might desire to become scholars had no access to writings or manuscripts except through the religious orders. In a short space of time these orders therefore controlled who should and who should not acquire the art of medicine, of mathematics, astronomy, or philosophy, and they used this "cornering of the market" solely and completely to their own uses and advantage.

The monasteries then devoted branches entirely to the practice of medicine; the men so chosen were called "medici." A little later on, one reads of "fisiceans" and "serorgiens" in the regulations and statutes of various established hospital staffs, as they have come down to us.

What the stock in trade of these "medici" consisted of, their armamentarium for the curing of disease, was about as follows:

First, and foremost, prayer, and the exorcism of devils. A loud voice and the ability to dance in contortions of extreme degree were attendant virtues.

Secondly, multiple forms and shapes, some symbolical, some not, of armlets and rings which were to be worn in some manner in or about where the ailment was seated. Some of these were worn in a preventive and prophylactic capacity to ward off and prevent the disease. These rings and armlets were made of metal, of tanned hides, of hair, or of leaves and branches of trees and shrubs.

Thirdly, herbs, gathered under varying zodiacal signs and influences, the moon in its proper phase, etc., then, finally, consecrated only by the priests themselves, otherwise efficaciousness was denied.

Fourthly, certain saints were "patron" saints of certain diseases, such as toothache, earache, etc., therefore, prayer was to be particularized and addressed to that certain designated saint if such a part were affected.

Fifthly, mineral stones, charms of various shapes and hues to be worn about the body or held in the hand. This latter custom has survived into our present day in certain foreign quarters of our large cities. Very respectable incomes are gathered by the dispensers of such.

To sum it all up, two characteristics stand out boldly in this armamentarium, gross superstition and blind unquestioning faith.

Nine hundred years later we see an enlightened (or at least a presumably enlightened) section of our own population existing under almost identical conditions. Superstition, exactly the same as that of old but clothed in the more modern speech of the modern faker, and faith, an incredulous blind stubborn indifference to thinking for oneself and a willingness to be led blindly. And yet, one could wager that the mortality rate in this group today, if such interesting statistics were possible to obtain, would show that the ancients' rate was lower because their faith was more simple, more blind, more primitive, and therefore, more honest.

If severe epidemic diseases such as leprosy, the plague, etc., occurred, decimating populations, these "medici" could never be accused of ignorance nor of dumbness. They merely avoided all responsibility by shouting from the housetops and

preaching everywhere that the Jews were responsible for the deaths because they had poisoned all the wells. Certain wells would then be tested publicly, accompanied by great ceremony and fol de rol, and found to be unfit for use, a certain number would be condemned and made unavailable for a time, a pogrom against the Jews was instituted, and there you had it—the solution. Could it be possible that the wells had been prepared beforehand for such public examinations in such manner as best suited such nefarious purposes? Attention was directed away from their own ignorance and incapacity into another direction. It didn't seem to matter, or perhaps nobody inquired, how it came to pass that these wells would be in use again after the plague had passed on.

It seems as though some of our master minds of today, particularly in the realm of politics, must have read or become acquainted with this technique of the ancient "intelligentsia" because they are using it to great effect in our own times, and with the same degree of success.

But the monks or "medici," drunk with their own power and position, began to indulge to such a degree in gross abuses—gluttony, extortion, blackmail, rape—that they became a sore spot and a liability to the Church. Conditions became so bad that in 1138, at Rheims, an edict was issued that the study of medicine and surgery in the monasteries was forbidden for the time being. From time to time up to 1250, similar edicts were issued at intervals.

Human biology and human characteristics being then about the same as today in their personal reactions, some of these monks continued to practice surreptitiously. The financial and bodily returns were sufficiently great as to justify the greed. Some of these doctors were most enterprising and in their own particular specialty stood out above those around them. They had advanced entirely on their own to the use of the actual cautery, live coals being used as the cauterizing agent.

Some had become quite skilful in the use of the knife or scalpel itself.

As an illustration of some of their attainments, Paulus of Merida, mentioned previously, performed the first cesarean section upon a living female, whether successfully or not is not known. Another, Theodorus, a Greek, was an expert at venesection; Notker of Prague, an expert on uroscopy; and a female physician, the Abbess Hildegarde, enclosed all of her remedies and herbs in a coating of dough, usually sweetened thoroughly, then baked in the form of little cakes or biscuits, and eaten. Nine hundred years ago, but what's wrong with that as a vehicle for bad tasting or noxious drugs? Hildegarde was quite proficient in materia medica, and was the supposed possessor of over two hundred secret formulae, all of which she dispensed in the above manner.

The libraries of the times consisted of written manuscripts which were handed down by inheritance, kept in the family for generations, and owned only by families of great wealth.

Perhaps the greatest scholastic influence upon medieval medicine were the three great schools of medicine of the time, that of Montpellier in France, one at Monte Cassino in Italy, and the school of Salerno, also in Italy.

Monte Cassino was founded by St. Benedict himself, and although it was against the newly announced principles of the order, the practice of medicine was encouraged and the school became much like a great clinic. The sick and ailing came from far and wide so that in reality the institution was forced to take upon itself the actual practice of medicine rather than the teaching of it.

As each abbot succeeded as head of the school, it was his custom to write a long treatise on the miraculous cures which had occurred under his leadership. About 1050 a great hospital was built at Monte Cassino and monks began coming from all quarters of the globe as students of medicine. The

story of Monte Cassino is of tremendous interest but does not lie in the sphere of this story.

The most famous of all of the monks who came to study at Monte Cassino was one Constantinus from Carthage, in Africa, therefore called Constantinus Africanus.

The Benedictins were responsible for putting medicine on the more solid and firm basis it acquired shortly after the year 1000. Their order had been founded about 500 years earlier but it is from this time on that they struck their stride and their work began to attract world attention.

In their monastery libraries were many of the writings of Hippocrates, translated into Latin, similar translations of Galen and Dioscorides, of Caelius Aurelianus, and an unknown quantity of manuscript matter of unknown origin and authorship, but all pertaining to medicine. Certainly an excellent foundation stone on which to build, and they did build. It was the availability of these old manuscripts for study which caused Constantinus to trace his steps toward Monte Cassino.

Shortly after arrival he was to stand out among all others there, because of his sheer intellectual ability. His life story is of sufficient interest to men in medicine to be repeated again and again, and will be a part of this series.

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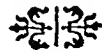
During the Napoleonic Wars, a French army surgeon by the name of Dominique Jean Larrey instituted so-called "flying ambulances," which permitted quick care of the wounded after their injuries and prevented innumerable deaths from infection from wounds contaminated in battle. His work led to the formation of the ambulance corp as it is known today. (Burbank)

The brief excerpts in this issue are taken from "Landmarks in Medicine," a volume of lectures to the laity given at the New York Academy of Medicine in 1938 (published by D. Appleton-Century Company).

⸢BOOK REVIEWS⸜

MODERN SURGICAL TECHNIC. By Max Thorek, M.D. Three volumes, with a foreword by Donald C. Balfour, M.D. Philadelphia, 1938. J. B. Lippincott. Price $35.00.

This work, one of the important publications of the year, is sure to receive a royal welcome from the profession. The author says he felt that "there existed a genuine need for a succinct work on surgical operations, up-to-date as regards important advances in surgical technic and including, in order to be practical, a sufficiently detailed description of each procedure in all commonly performed operations." With these thoughts in mind he has written three volumes to supply this need.

The highlights of surgical anatomy occupy a goodly space. Also, such operations as amputations, ligation of blood vessels, fractures, dislocations, etc., are amply dealt with. The step-by-step (the most practical) method has been adopted in describing operations. This is especially helpful to the surgical intern, the neophyte, and the young assistant.

The illustrations (2,174 in number) are modern and far above the average. Most of them are by Mr. W. C. Shepard, outstanding in his field.

Volume I is divided into two parts, the first of which deals with general operative considerations, covering such interesting chapters as "The Surgeon and His Art," "The Surgeon and His Patient," "Operating Pavilions and the Operation in General," and "Anesthesia." Part Two covers surgery of the head and neck and plastic surgery. The second volume contains Parts Three and Four: Part Three has to do with the surgery of nerves, vessels, and bones, while Part Four deals with surgery of the breast and chest. Volume III contains Parts Five and Six. Part Five considers surgery of the abdomen, while Part Six concludes with surgery of the pelvic region. An author index and a subject index are complete at the end of each volume.

This is a well written piece of work—and it is not padded. Any graduate of medicine can follow a description of an operation step by step and have a very good idea of what it's about.

Surgical interns and residents, and young assistants to seasoned surgeons would do well to add these volumes to their libraries. They will refer to them constantly and with profit. Dr. Thorek tells us it is "intended particularly for students, for general surgeons and for those general practitioners who are occasionally called upon to perform emergency operations." He has followed his blueprint to the nth degree.

Dr. Donald C. Balfour has provided a short but superior foreword.

Dr. Thorek is to be commended and congratulated in completing this needed work, and in turning out such a finished workmanlike job. A bow is offered to the publishers also, for giving us three good looking volumes, well printed, and with illustrations excellently reproduced.

THE RELATION BETWEEN INJURY AND DISEASE. By Jewett V. Reed, B.S., M.D., F.A.C.S. and Charles P. Emerson, A.B., M.D., D.SC., with the collaboration of E. B. Mumford, B.S., M.D., F.A.C.S. Indianapolis, 1938. Bobbs-Merrill. Price $7.50.

This carefully and well written book fills an acute need at the present time. The authors frankly tell us it is intended for three professional groups: officials of insurance companies which carry the various types of casualty risks; lawyers who present, either pro or con, accident cases before courts and boards; and physicians and surgeons.

We are informed that "On the basis of so-called 'expert medical testimony' a new and strange pseudo-pathology has been slowly evolving in the Courts. . . . The responsibility for some, but by no means all, of the mistaken testimony of physicians in accident cases rests with medical textbook authors who 'round out' their paragraphs on the etiology of too many diseases by the words 'and injuries,' a statement which they have copied and recopied from their predecessors of several decades ago, although in the case of many diseases the progress of medicine has exposed this as an error. . . . Physicians responsible for the care of injured persons in whose condition there is the element of liability are impressed by the unfairness of many settlements made . . . many injured

persons receive little or nothing for physical disabilities and impairments justly compensable, while others receive awards for diseases not in the least due to injury."

The purpose of the book is to reduce the number of such injustices in both directions.

The book is 577 pages long and well indexed. The authors cover the subject adequately and have resorted to no padding. We venture that this work will find its way into many offices, including many not medical, and will be frequently quoted in courts.

A TEXTBOOK OF MEDICAL BACTERIOLOGY. By David L. Belding, M.D. and Alice T. Marston, PH.D. In collaboration with Sanford B. Hooker, M.D., Sidney C. Dalrymple, M.D., DIP. BACT., Jose P. Bill, M.D., P.H., and Matthew A. Derow, M.D. New York, 1938. D. Appleton-Century. Price $5.00.

This is a concise and yet comprehensive textbook of medical bacteriology, standing between the weighty reference books and the light simple texts. The book is purely and simply a teaching text. Only such recent advances as have proved their worth have been included.

Emphasis is placed upon the relationship of bacteriology to public health and preventive medicine. Immunity is presented as a distinct entity. Because of the increasing importance of the fungi and the ultramicroscopic viruses, a relatively greater amount of space than usual has been devoted to them.

The line drawings are purposely diagrammatic rather than photographic, and are the work, as are the other illustrations, of Mr. C. E. B. Bernard.

The book represents the coöperative work of the members of the departments of bacteriology, public health, and preventive medicine of the Boston University School of Medicine.

There are 549 pages of text, an appendix (including special methods of staining, formulae for culture media, and technical methods), two pages of supplementary references, a list of journals useful for reference, a glossary, and an index.

PLASTIC SURGERY. By Arthur Joseph Barsky, M.D., D.D.S. Philadelphia, 1938. W. B. Saunders Co. Price $5.75.

This small book (355 pages) is a clinical evaluation of methods. The author tells us the work offers procedures which have proved successful in his hands and in the hands of other workers. The author has stuck to his guiding aim—to convey by word and by picture the principles and practice of modern plastic surgery.

Among the subjects considered we may mention: free skin grafts; flaps and tube pedicles; transplantation of tissues other than skin; treatment of wounds; burns and frostbite; scars and keloids; the orbit; the nose; the ear; harelip and cleft palate; lips, cheeks and jaws; fractures of facial bones; the neck and trunk; orthopedic aspects of plastic surgery; the extremities; and prostheses.

The illustrations, mostly line drawings, are very good. There is a bibliography at the end of each chapter. The author has an easy style in writing and holds the attention of the reader.

The surgeon who intends doing more or less plastic (we hear it's now called "construction") surgery will do well to consider studying Dr. Barsky's text.

CANCER—ITS DIAGNOSIS AND TREATMENT. By Max Cutler, M.D. and Franz Buschke, M.D. Assisted by Simeon T. Cantril, M.D. Philadelphia, 1938. W. B. Saunders Company. Price $10.00.

We read in the preface of this splendid book, "The special purpose of this work is to make accessible to the reader a critical evaluation of the pertinent facts in the diagnosis, prognosis and treatment of cancer as gleaned from the world literature and reviewed in the light of our own experience." The authors tell us they have left to existing treatises the presentation of such highly specialized forms of cancer as those of the central nervous system (Harvey Cushing and Loyal Davis). Also, that only those aspects of pathology are discussed which appear to have a direct bearing upon the clinical management of the disease. Questions of histogenesis and detailed morphology have been left to other works (Ewing).

The authors realize that the important thing is the early detection and diagnosis of cancer. Therefore the work is addressed to the general practitioner as well as the specialist.

This book (757 pages), is interesting and instructive reading. The illustrations are espe-

cially good. An extensive bibliography is included, as are author and subject indexes.

LES ULTRAVIRUS DES MALADIES HUMAINES. By C. Levaditi and P. Lépine. Volumes I and II. Paris, 1938. Maloine.

Our knowledge concerning the ultraviruses and the human diseases they cause is progressing so rapidly that it is impossible for one individual to assimilate it all and to separate what has been firmly established from what is as yet unproved. For this reason the authors have considered it useful to publish a work in which each subject is treated by an author who has made individual contributions and who has the perspective necessary to separate fundamental facts from those that should be kept in the background.

They have produced a work that is authoritative and well documented and yet does not pretend to be an encyclopedia. Those virus diseases about which our knowledge is still uncertain have been omitted. The authors have tried to bring to the reader, whether he be a clinician or man of the laboratory, a view of the whole subject and at the same time to place at his disposal the more important source material. The book is an excellent piece of work and represents the best that comes from French science today. It belongs in the library of every man seriously interested in the virus diseases.

SENSIBLE DIETING. By William Engel, M.D. New York, 1939. Alfred A. Knopf. Price $2.50.

We have, in our time, read many books on diets and dieting, some fair and many terrible. Too often they are written by food cranks who have never heard of the science of physiology. It is therefore with considerable relief and pleasure that we picked up Dr. Engel's sound and conservative book. We chuckled in some parts, but learned many things for the first time, and continually marvelled at the author's ability to pack so much in a minimum of words.

This book gives ample evidence of having been written by a physician who knows and believes in proved scientific facts, and who has only ridicule and disgust for the thousand and one food fads which have assailed us during the past two decades. He disposes neatly of commercial food advertising, of claims for creams which "melt fat," for bath salts which "re-duce," and for massage which can "take it off" here and there. One discovers why exercise is a poor reducer.

Not the least remarkable feature of the book is the 300-page section devoted to actual menus, suitable to the various seasons and yielding varying caloric contents. There is a series of daily menus, covering a week's time, each day's food allotment producing 1,000 calories. Other series step the caloric yield up, with gradual increases to 2,000 calories.

The common sense which rules throughout makes this book profitable both to physicians and to laymen. It is just the thing to suggest to a patient who has requested a diet to rid him of 20 to 40 pounds of excess weight.

FUNDAMENTALS OF INTERNAL MEDICINE. By Wallace Mason Yater, M.D. New York, 1938. D. Appleton-Century Company. Price $9.00.

Dr. Yater tells us his volume "is designed primarily for the introduction of students to the subject of internal medicine, [and] is intended to provide the foundation upon which the superstructure of more detailed and extensive knowledge may be built." Fractures, dislocations, obstetrics and strictly gynecologic diseases are excluded. Otolaryngology, ophthalmology and dermatology are included only for the information that an internist or general practitioner should possess. Only rotational therapy of proved value has been included, and tables of differential diagnosis have been prepared to simplify the subject.

The author has called to his assistance several of his associates in the preparation of certain sections of the book. The whole is 1,021 pages long, with 255 illustrations, and an ample index.

It is a good book, recommended without reservations to general practitioners and internists.

THE PHYSIOLOGY OF ANESTHESIA. By Henry K. Beecher, M.D. New York, 1938. Oxford University Press. Price $3.75.

Any one interested in the subject of anesthesia, whether he be an anesthetist, a surgeon or a technician nurse giving anesthesia can well read this book with profit. The author says that the material he presents was originally used in teaching the fundamentals of anesthesia to the Harvard medical students. His plan of presen-

tation is to describe the response of the body to anesthetic agents and to anesthesia.

The following broad topics are considered in more or less detail: effects of anesthesia on the nervous system; respiration and anesthesia; circulation and anesthesia; and organic effects of anesthetic.

This book of 388 pages is well written, has the ring of authenticity, and leaves little or no room for criticism. It has an extensive bibliography and an ample index.

Cabot's Physical Diagnosis. By Richard C. Cabot, M.D. and F. Dennette Adams, M.D. 12th Edition. Baltimore, 1938. William Wood & Co. Price $5.00.

Over thirty years ago we used Cabot's "Physical Diagnosis" as our textbook—it was born thirty-eight years ago. The new twelfth edition is still covering this important subject scientifically and interestingly.

The present edition has been completely rewritten on a new basis that recognizes the progress of present day physical diagnosis.

This standard text (standard in every sense of the word) is 846 pages long, has 391 illustrations, and an ample index.

The book is beyond praise. It will continue to be the first choice of teachers, should be owned by every student of medicine, and is a "best buy" for the up-to-date old grad. A lot of book, all solid gold, for very little.

. The Surgery of Oral and Facial Diseases and Malformations: Their Diagnosis and Treatment. By George Van Ingen Brown, M.D., D.D.S., F.A.C.S. 4th Edition. Philadelphia, 1938. Lea and Febiger. Price $10.00.

We are offered the fourth edition of this popular work, a standard text designed for students, but at the same time a reliable source of reference for practitioners of medicine. The importance of plastic surgical reconstruction has made it necessary to detail what can be accomplished by surgery in this field. The author has included drawings of the operative steps employed in such surgical procedures, and gives the reasons for their selection.

This book is 778 pages long, has been thoroughly revised, and has 1,019 illustrations, 12 colored plates, and an index. It can be rated A-1.

Classic Descriptions of Disease. By Ralph H. Major, M.D. 2nd Edition. Springfield, 1939. Charles C. Thomas. Price $5.50.

Dr. Major's work is an ideal gift for a medical friend. If you yourself do not own a copy, we hint that you buy one. Many hours of satisfying reading await you, since this is manifestly the book to turn to when the work-day has ended. You can open it at random and start to read.

There are 403 selections from the original epoch-making accounts of 190 authorities, whose contributions and discoveries provided the foundations of modern clinical medicine. The entire field of medicine and its development from the the author of the Papyrus Ebers to discoveries of modern times is covered.

This beautifully printed book of 727 pages has 137 illustrations and 993 index references. This second edition includes much new material.

The Treatment of Fractures. By Charles Locke Scudder, M.D., F.A.C.S. 11th Edition, Revised. Philadelphia, 1938. W. B. Saunders Company. Price $12.00.

The first edition of this book appeared in 1901, and from that time until 1926, ten editions were published. During the past twelve years many new advances in the diagnosis and treatment of fractures have made "it necessary, in order to meet these new conditions and to include all these many advances, to rewrite the book completely." All obsolete methods have been omitted and new methods of treatment and diagnosis have been added.

For the presentation of special fracture problems the author has turned to men actively engaged day after day in handling these problems. It would add to the worth of many books if this method was followed more often.

The general surgeon and the general practitioner are given clear and clean cut guidance in meeting fracture problems. First aid is emphasized. Since the general practitioner is usually the first to see a fracture the first aid underlying principles are important if one is to get full restoration of function.

This book of 1,208 pages, has 1,717 illustrations, many of them new, appearing for the first time in this edition. The index covers twenty-three pages.

A book which has lived for three or more decades and has gone into over ten editions needs no further favorable comment.

THE ESSENTIALS OF MODERN SURGERY. Edited by R. M. Hadfield-Jones and A. E. Porritt. Baltimore, 1938. William Wood and Co. Price $9.00

The editors of this book felt that there was a real need for yet another textbook of surgery. Most books are either tomes of two or more volumes or else handbooks of small size. Between these, the editors felt, there was room "for a single textbook in which surgical teaching is based on the fundamental principles of anatomy, physiology and pathology." The editors' object has been to provide students and practitioners with the essentials of modern surgery in concise form in a book which would be "of practical use to students studying for the higher examinations." Thirteen colleagues have coöperated with the editors in compilation.

The reviewer agrees with the editors that such a book has no space for the details of operative treatment. No details of technique have been included except in a few instances. The volume contains 1,126 pages, has 501 illustrations and an index.

The Evaluation of Surgical Procedures on Bones, Muscles and Peripheral Nerves in Spastic Paralysis

BY

ARTHUR A. THIBODEAU, M.D.,

LEWIS CLARK WAGNER, M.D.

AND

FRANCIS J. CARR, JR., M.D.

THE EVALUATION OF SURGICAL PROCEDURES ON BONES, MUSCLES AND PERIPHERAL NERVES IN SPASTIC PARALYSIS*

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INTRODUCTION

THE problem of treating children afflicted with cerebrospinal spastic paralysis has always been a bewildering one, presenting in its literature only a conflicting mass of material. The subject has been approached from many different points of view, but there has been no analysis of the result of the massive amount of research, experiment and actual treatment.

Surgery has always been the foremost element in the treatment of spastics, and much of it has been done that has been helpful, much harmful. It seems that few surgeons have a thorough knowledge of the worth of some of the existing surgery. As a whole, postoperative study in surgery of spastic paralysis has been neglected.

In order to accomplish this, an attempt has been made to review the cases in the Hospital for Ruptured and Crippled which have undergone operation, and to evaluate clearly and definitely their results. Nothing is herein to be considered original. As in any review of the literature of such a large subject, many things may be overlooked, and due apology is made to the authors at this time.

HISTORY

In the year 1843, William J. Little, in his course of lectures on the deformities of the human frame, discussed a spasmodic affection which he thought was produced at the moment of birth, or within a few hours or days of that event. He felt that this was due either to prematurity, the difficulty and slowness of parturition causing asphyxia, or to the deteriorated health of the parent impairing the normalcy of the fetus.

This heretofore unknown entity thus obtained its name, and Little's Disease has continued to be a problem to the obstetrician, the family physician, the neurologist, the surgeon, the parents, as well as to the patient himself.

Little continued to investigate this condition throughout his life and again elaborated its description in 1853. In 1862 he wrote a complete article, at which time he stated that in his private practice he had treated over 200 cases traceable to causes operative at birth and propounded the theory some abnormal act connected with the mode of birth was the cause. He attempted to treat these cases armed only with tenotomies to release rigidity and spasticity, the practice of which he and Stromeyer were the first advocates.

This was the situation until Foerster in 1908, with his theories of the mechanism of the reflex arc and spasticity, advised a section of the posterior spinal roots which supplied the affected extremities. He presented excellent results which were confirmed by his associates and others.

However, this procedure soon passed into the background and not many who were treating those patients took to it.

An entirely new concept was brought forth in 1924 by Hunter and Royle, who described an operation of sympathetic
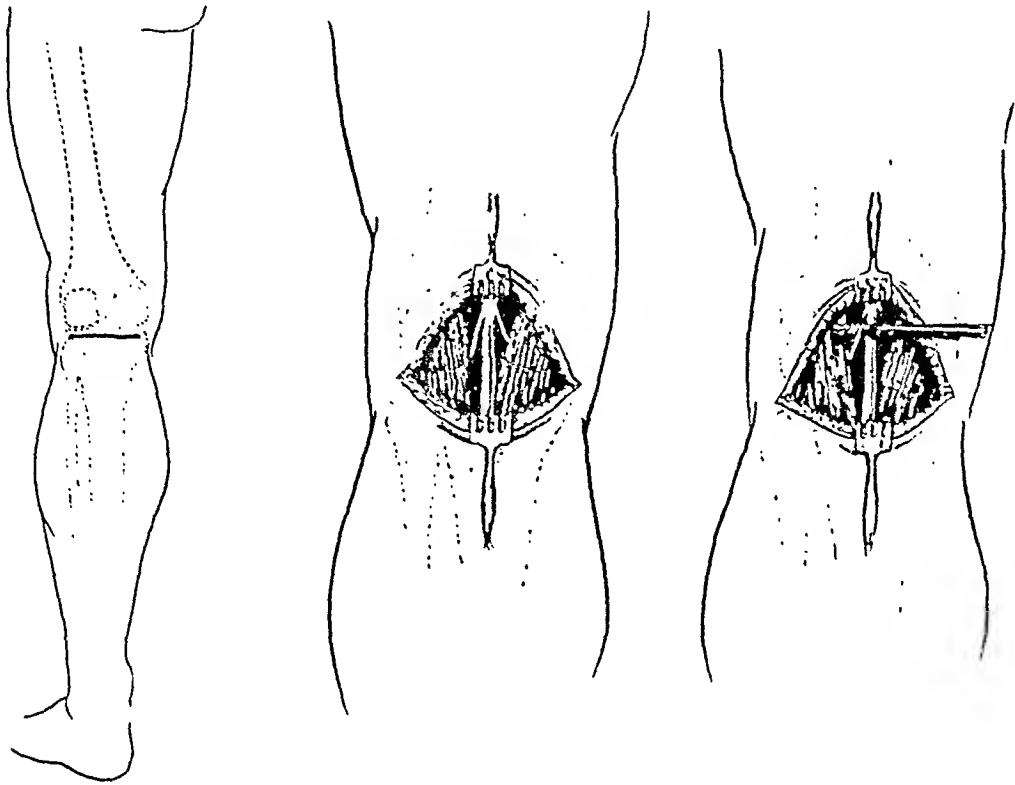
Fig. 1. Stoffel's operation (gastrocnemius).

In 1912, Stoffel brought forth his principles of treatment which have continued to be, up to and including the present time, the most significant in the care of spastics. Not only has his work been proved by his results, but it has been universally confirmed. Stoffel did not offer a cure for spasticity, but so improved these patients' functions and capabilities that they were able to take their places as useful members of society, able to look after themselves.

In 1915, Sharpe and Farrell stated that, after considerable study concerning the mechanism of labor in childbirth, the condition of the infant at birth, the signs presented and the progress in childhood, they felt that a very large percentage of these cases were due to increased intracranial pressure caused by hemorrhage or trauma. They recommended as the appropriate treatment cranial decompression, and reported evidence of improvement following operation, as well as the findings at operation.

ramisection and provided an experimental basis for it.

A few years ago, Phelps began to classify these patients as to types. It became clear, then, that the treatment of each case had to be absolutely dependent upon the type of patient, one treatment differing from another. He brought out very definitely the fact that thorough study of each patient was necessary and that rehabilitation could be obtained by muscle reëducation and training.

At the present time, Putnam is, by neurosurgical experiment on the extrapyramidal tracts, showing that a tremendous improvement can be made in the control of athetosis.

ETIOLOGY

Cerebrospinal spastic paralysis in orthopedic practice is second in frequency and importance only to anterior poliomyelitis. Much has been done in the investigation into the cause of the condition.

Sachs has suggested probably the simplest classification regarding the time of occurrence: antenatal, natal and postnatal.

hemorrhage from venous or arterial rupture, as the result of trauma or as a spontaneous occurrence in intense congestions

FIG. 2. Bilateral Stoffel operation and lengthening tendo Achilles.

It is not always an easy task to determine the etiology in the individual case, as so many come under observation late, when the signs have lost their intrinsic identities and have taken on similarities.

The cerebral lesions having their origin in utero, or antenatally, depend primarily on conditions affecting the mother secondarily on the fetus or its maldevelopment.

In the natal group are those palsies dependent on intracranial hemorrhage, which is either the result of trauma to the infant's head during a precipitate labor, prolonged labor, forceps delivery, breech delivery, or possibly the result of prolonged asphyxia at birth.

In addition to the cranial injuries, definite evidence of spinal cord injury has been reported by Studdiford, and references have been made to this type of injury by Crothers.

In the postnatal group, we have the statement by Butler that spasticity coming on in childhood may be caused in one of three ways: first, vascular lesions, such as

such as convulsions, paroxysms of whooping cough, embolism from cardiac or arterial thrombi, endocarditis, occasionally in endarteritis and thrombosis; second, spasticity may be caused by inflammatory changes such as acute encephalitis, meningo-encephalitis, and polioencephalitis; third, it may be caused by brain tumor, which can be usually differentiated by progressive signs and symptoms.

PHYSIOLOGY AND PATHOLOGY

The study of the nervous system suggests at once its functional place in the human body. The vast connections of this system with all parts of the body indicate the possible channels through which information is received of the state of environment, and of the condition of the different organs engaged in carrying on the processes of life. Fashioned together as one structure, intimately connected and related in all its parts, the brain and spinal cord serve admirably the function of directing, coördinating and controlling the activities

of the body. The nerves of the system are merely the pathways by which messages are brought to the central station, the

As long as the reflex arc is dominated by these higher centers, there is a braced up condition in the muscles, which is called
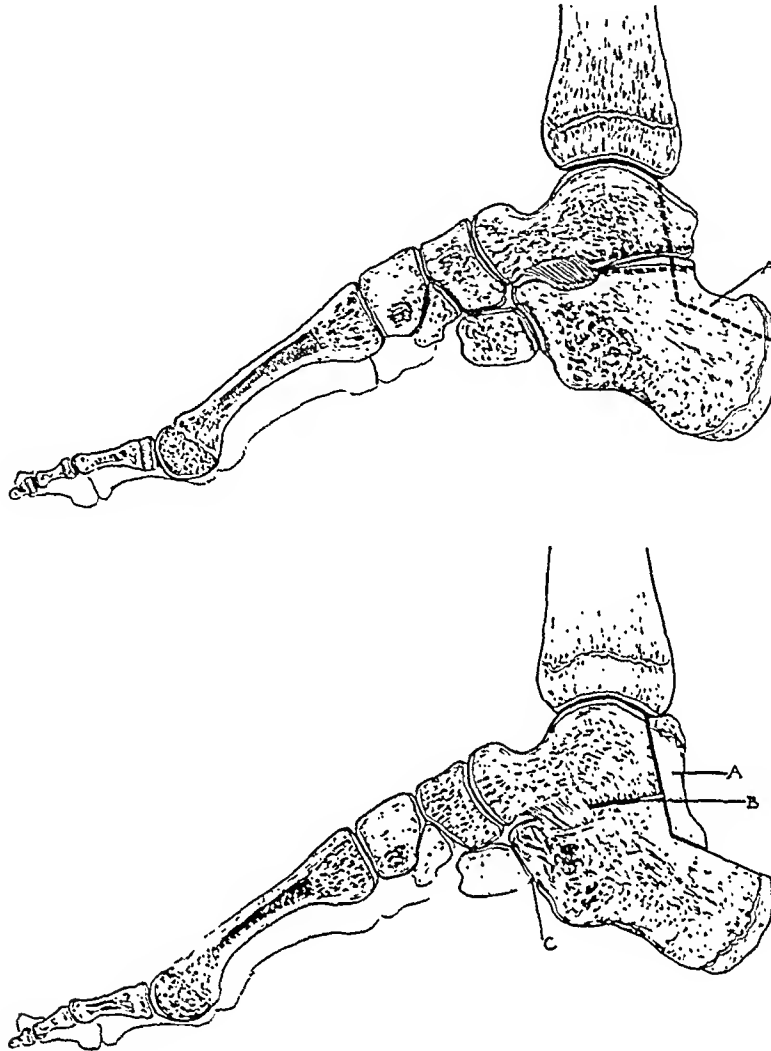
FIG. 3. Posterior bone block.

brain, and directions are sent out to the outlying agents that will put into effect the orders received. Thus the movements of muscles are under the supervision of this structure, the nervous system.

If the highly organized central nervous system is to have a broad field of endeavor worthy of its powers, locomotion must be easy and rapid and all segments of the nervous system must work in exact coördination. Anything disrupting any part will lead to difficult uncontrollable locomotion.

The cord is responsible for the simple reflex motor act. It is also made up of ascending and descending tracts which relay these impulses to the centres higher up in the brain stem, basal ganglia, and cerebral cortex.

reflex tonus. This tonus is the basis of all postural reactions.

It is generally believed that all muscle tonus is controlled in the high centers. There apparently is a state of inhibition affecting muscles, which prevents the reflexes from acting continuously at their strongest force; it also prevents complete relaxation affected in agonists and antagonists. Just where this inhibition is effective, no one is sure, but it is felt that it does take place in the upper nervous system.

It can easily be seen that any disturbance in the corticospinal system would lead to abnormality in tonus, coördination or control. And, as this system is upper motor in type, spasticity will result unless the damage is without the direct tracts

such as in the lenticular or cerebellar region, in which case disturbance of coördination and balance will take place.

and so forth, are incompatible with life, but other types of agenesis or lagging development and growth may occur. Fre-
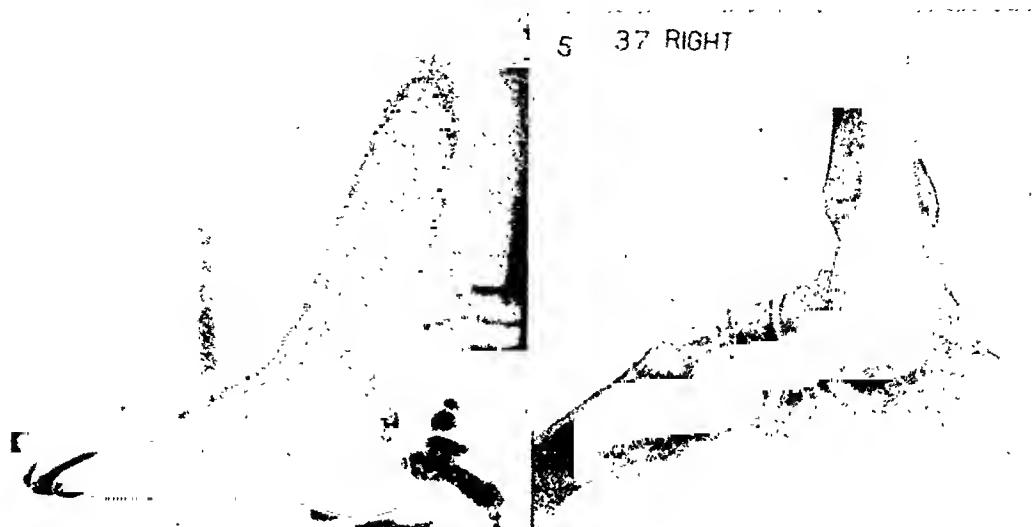
FIG. 4. Posterior bone block.

Just what these lesions are pathologically calls forth considerable disagreement. Cases which have come to autopsy have varied. This, of course, is to be expected because

quently this lack of development may lead to spasticity of the diplegic type with mental deficiency. Microscopic examination in cases of this group at times shows
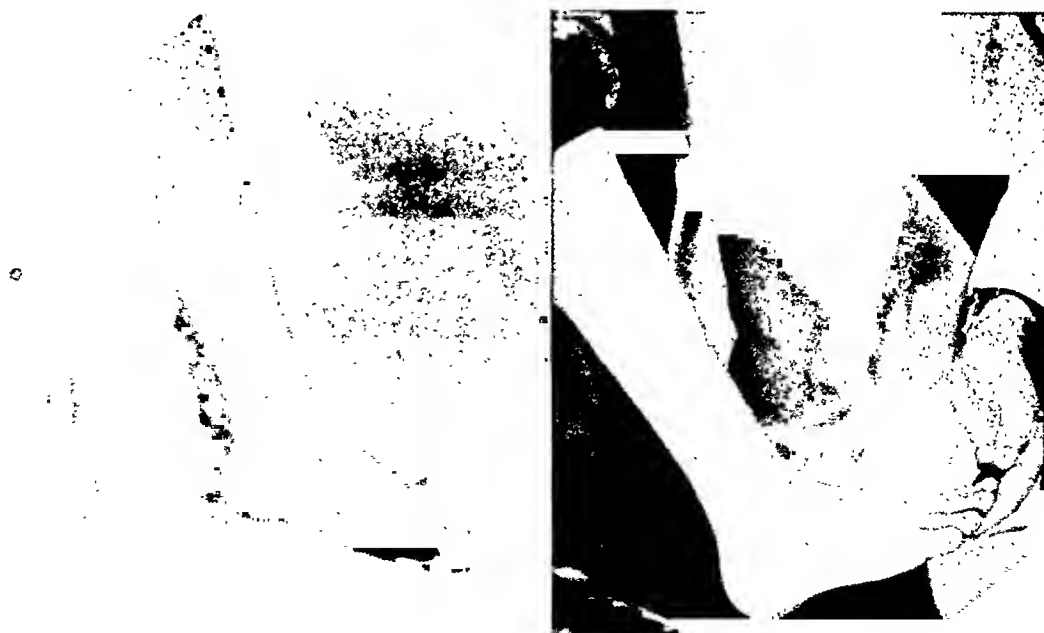
FIG. 5. Posterior bone block—limits of motion.

of the difference in etiology. The anomalies no doubt cause a large percentage of the prenatal group. The gross types, such as anencephaly, iniencephaly, notencephaly,

no pathologic lesions whatsoever, but occasionally may show a disarrangement of the normal pattern. At times, large, degenerative or cystic areas, porencephaly, are

found. Collier concluded that it was a primary neurogenic degeneration.

In the natal or birth injury group, the

FIG. 6. X-ray of previous case.

pathology is more definite. If a lumbar puncture was done routinely on newborn infants, one would find a rather large percentage of bloody taps. No doubt the incidence of cranial damage is much greater

stretching of tissue to marked hematoma and complete rupture of the cord. The late lesions show fibrosis and degeneration of the cord.

In the postnatal group, injuries causing hemorrhage may present the same findings as in the birth injury group. Syphilis may cause late development of spasticity due to rupture of weakened vessels, or the condition may cause adhesions between the dura and pia-arachnoid. Often in late cases, there are seen cellular foci or granulomas with necrosis of normal cell tissue. Occasionally vessels are obstructed and local encephalomalacia occurs.

In the cases occurring after scarlet fever and measles no doubt acute serous meningitis was present. This is an affection of the pia-arachnoid, often of the cortex, characterized by congestive hyperemia, edema and the production of an exudate.

In the various purulent meningitides, permanent damage may be done to the membranes and even the cortex. Degeneration of the involved tissues results in

FIG. 7. Bilateral posterior bone block.

FIG. 8. Posterior bone block.

than one would think, but usually it is so slight, no evidence is seen and the children progress normally.

In the cord, the pathology ranges from merely perivascular hemorrhages and

scarring or pulling by adhesion to produce disturbance in the normal mechanism of the cerebrospinal nervous system.

When spasticity follows encephalitis, the pathology is about the same, the type

depending upon where the greatest process has taken place. It may be of a cortical type, called meningo-encephalitis, or it

Fig. 9. Stoffel operation of obturator nerve.

motor action of a muscle is increased, and also is counteracted by its antagonists.

Athetosis, which is seen about as fre-

may be in the grey matter, called polio-encephalitis. Microscopically, there is a destruction of cells with the formation of sclerosed areas or fibrous scar.

After these children grow older, the pathology is not differential. One can find approximately the location of the lesion, but one cannot definitely say whether it is of prenatal, natal or postnatal origin. Therefore, the history is of great importance, and the treatment must be guided by the status of the individual.

SURGICAL DISABILITIES

As stated by Phelps, this type of patient has always been considered from a neurologic standpoint. The various lesions have been described, but not much has been offered to correct them. Therefore, one must consider this problem from its disabilities.

Spasticity is the most common disability. There is hypersensitivity of muscles to any stimulus they may receive, whether they be from within the body or without. Any

quently as spasticity, is the next disability. This manifests itself by constant contractions of successive muscle outside the control of the patient. It varies in intensity and does not seem to be affected by voluntary contraction. One will notice these patients when at rest constantly moving.

Now we come to the deformities which may result from imbalance of muscles. In cases of spasticity, the limbs seem to assume an atavistic position. Groups of flexors constantly spastic will outdo the antagonists and, though the latter are spastic too, in most instances they become elongated or weakened. For instance, the knee is a good example. The hamstrings are so much stronger than the quadriceps that the latter does not seem to have the ability voluntarily to extend the knee completely. Very often the patella is found very much higher than normal when the knee is passively extended. These joints, if they have been allowed to remain in abnormal positions any length of time,

will lead to structural changes. That is, there may be capsular and ligamentous contractures and the predominant muscles

should be made first to determine whether the condition is progressive or not. The mental status, too, was found to be of
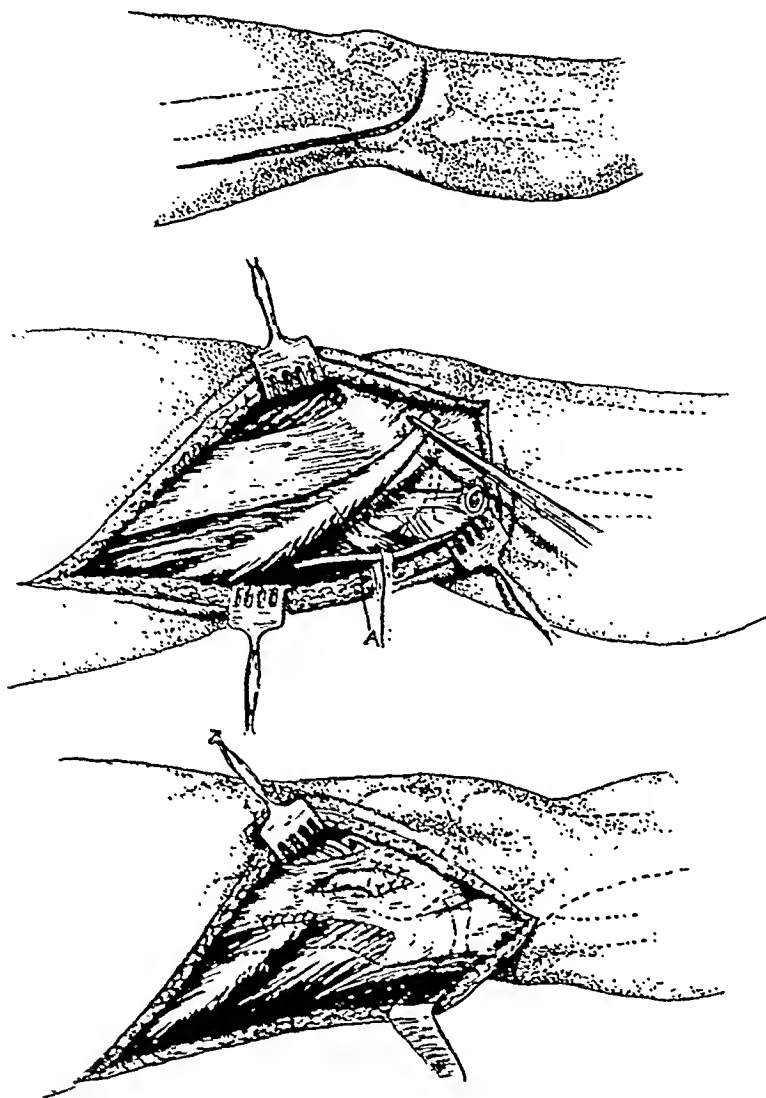
Fig. 10. Transplantation of biceps femoris muscle to patella.

will contract. The deformities frequently seen are torticollis, adduction and internal rotation of the shoulder, flexion of the elbow, pronation of the forearm, flexion of the wrist and fingers, also adduction of the latter. In the lower extremity, adduction and flexion of the hip, flexion of the knees, flexion of the ankle, and deformity of the foot and toes are often present.

TREATMENT

Writers for many years have spoken of the value of training spastics, but it was not until Phelps began classifying the types and giving individual training to each that much was thought of this method of treatment. Phelps feels that a diagnosis

great importance, for, if a child is mentally deficient, it is useless to attempt reëducation, or even to attempt surgery unless it is to improve him for home care.

In mild cases, muscle reëducation, if properly administered, will give almost a perfect result. In the more severe cases, it is variable. We are aware that it takes years to accomplish this work.

The normal child habitually begins school at about the age of 6, but many spastic children never have any education whatever. The result has been that these patients have been doomed as mentally deficient. However, like normal children, they are entitled to education. If special classes cannot be formed for them, indi-

vidual training should be given by tutors or parents. A large number can be accommodated in the regular schools.

FIGS. 11 and 12. Bilateral biceps transplant.

Speech difficulty is one of the most common disabilities of spastic and athetoid children. Along with their other treatment, they should have training of this type also.

There is no doubt that muscle training plays a very important part in the rehabilitation of these patients and many are almost completely relieved by its application, but there are others who are very severely affected with whom nothing can be accomplished. It is these cases which have led physicians to seek other methods of treatment of a surgical nature.

In 1908 Foerster published his theories of spastic paralysis. He did a laminectomy to cut the posterior roots. The sensory impulses were reduced and the spastic symptoms diminished. He felt that as long as the muscles were spastic because of involuntary sensory excitation, they could be relieved by this procedure. He did not advocate it in cases of athetosis, but only in selected cases of extreme spasticity.

The patients were relieved of their external spasticity but their structural deformities, if they had developed, still remained. All of his patients had an extensive course of muscle training afterward, along with orthopedic corrections when necessary.

This work was confirmed by Clark and Taylor who stated that there was tremendous improvement, with no significant sensory disturbance afterward. Also Hey Groves, Blahd, and Frazier reported good cases.

It is important to notice that all writers advocated this procedure only in very severe cases of spasticity and that, following the operation, many were left flaccid, but in time regained their reflexes. This may explain why the procedure has not become more popular. It is probable that patients continued to regain muscle tone to the extent of becoming spastic.

In 1912, Stoffel wrote about an operation which he developed to reduce the spasticity of the individual muscles. He agreed with Foerster regarding the physiology of the condition. In his investigations, he found that each muscle could be divided into several sections and that they, in turn, could be subdivided. In other words, each group of 100 to 200 muscle fibers was innervated by one nerve fiber. The stimulation of one gave a twitch and all gave a muscle contracture. He stated also that functions of the joint were carried out not by a single muscle but usually by groups of muscles.

Therefore, he believed that, by cutting part of the nerve funiculi in a motor nerve, the same effect could be produced that is produced in a muscle in anterior poliomyelitis. Part of the muscle would be paralyzed. In groups of muscles, part of the group could be paralyzed by cutting the entire innervation of the muscle. He advocated that this be done near the point of entrance of the nerve to the muscle, as in the case of the gastrocnemius. When this is impossible, such as in the case of the flexors of the legs, the procedure was to split the muscle nerves into its component parts higher up at an easily accessible place, and cut some of the fibers to the muscles to be weakened. If, for example, the operator wishes to weaken the pronator teres, the median nerve is exposed at the lower arm. After separation of the branches, they are touched with a needle electrode to determine the proper branch.

Stoffel stated that the postoperative treatment was important. Training of the patient should be begun as soon as the wounds are healed. The result was not often immediate, but appeared only after reëducation. He also stressed the fact that one should be careful not to paralyze too much muscle as the antagonists could very easily produce the opposite deformity.

This work has been confirmed by Dickson, Gill, Heyman, Ryerson and others.

Not long after the advent of peripheral nerve surgery for the relief of spasticity,

Sharpe and Farrell, and later Sharpe alone, stressed the importance of intracranial hemorrhage in the newborn. Previously, it

Fig. 13. Bilateral biceps transplant—incomplete extension.

had been considered a chronic condition and only the end result was considered. They felt that the diagnosis should be made earlier and decompression done to relieve the pressure, so that further damage to the brain might be prevented. Early lumbar puncture in doubtful cases would determine the presence of blood in the spinal fluid. Repeated punctures were recommended to relieve the pressure at first, later to be followed by operation if improvement were not permanent. Many cases of subdural, supracortical and subarachnoid hemorrhage were found at operation. In the more chronic cases, operation was advised when signs of increased intracranial pressure were found. The eye changes seen were described by Kearney.

This work was carried on for many years with repeated good reports. Lately von Briesen stated that neurosurgical treat-

ment by craniotomy or spinal drainage in cases of localized meningeal hemorrhage at birth may prevent subsequent brain

The work of Hunter and Royle, which came upon the world as a cure for spasticity, was only short lived, even though

FIG. 14. Biceps transplant.

damage. He also stated that the late neurosurgical treatment after pathology has become static is beneficial only to a limited degree, the benefit being most marked in cases which at operation had corticodural adhesions.

many good results were reported. It was their contention that spastic paralysis could be relieved by destruction of the sympathetic innervation to the affected muscles. They offered experiments to substantiate their views and reported cases.

No doubt there was improvement in the patients, as this was confirmed by Stewart, von Lackum, and Carrell. It was felt that this procedure would reduce the plastic tone and was indicated in only those cases which had it.

Kanavel and associates would not confirm the work as by experiment they could not prove its value. They felt there might be some effect on muscle tone by a vaso-motor or chemical change.

As stated by Phelps, there were certain cases of athetosis which would not respond to any type of conservative treatment. The operations mentioned have all been indicated, if at all, only in cases of spasticity. Athetosis, as mentioned before, is due to pathology in the lenticular region and its connection with the muscles is the extra-pyramidal tracts.

Putnam has been doing a section of the extrapyramidal tracts. In twenty cases of athetoid syndrome, an operation was carried out, consisting of section of the anterior quadrant of the cord above the brachial enlargement on one or both sides as indicated. In addition, section of the first three anterior roots and the spinal accessory nerves was performed in cases in which torticollis was a prominent symptom. Two patients in the series died after operation from causes which he feels should be avoidable in the future. All the rest showed improvement with the exception of two. This work has also been started by Eric Oldberg of Chicago, whose cases show improvement. The above is encouraging and no doubt will offer some relief for those severe cases which have been so much of a problem in the past.

From what has been said before concerning the treatment from a surgical standpoint, there does not seem to be any one procedure or type of procedure which will answer for the cure or improvement of these cases. Therefore, it is the feeling that we still must consider each patient as an individual problem.

Such has been the situation at the Hospital for Ruptured and Crippled. Training either at the hospital by physiotherapists or at home has been advised to nearly all, accompanied by surgical procedures for

Fig. 15. Biceps transplant—incomplete extension.

the relief of spasticity or correction of deformity when it seemed necessary.

From 1926 to 1937, 1831 cases of cerebrospinal spastic paralysis were seen in the out-patient department of the hospital.

CHART 1
CEREBROSPINAL SPASTIC PARALYSIS
Hospital for Ruptured and Crippled

		Cases
1926 to 1937	Seen in O. P. D.	1831
1926 to 1937	Admitted to hospital	380
End result study	Operative	210

Operations

Equinus deformity of foot	209
Adduction deformity of leg	123
Flexion deformity of knee	81
Other deformities of foot	49
Flexion deformity of wrist	49
Pronation deformity of forearm	4
Deformities of the hand	3
Spasm of the neck	1
Deformities of the hip	17
Deformities of the toes	10
Sympathetic ramisection	8
Total	554

Three hundred eighty cases were referred into the hospital for operation. In a recent review, it was possible to obtain an end

noted that stretching of the tendo Achilles was unsuccessful. It is logical that recurrence of the deformity would take place
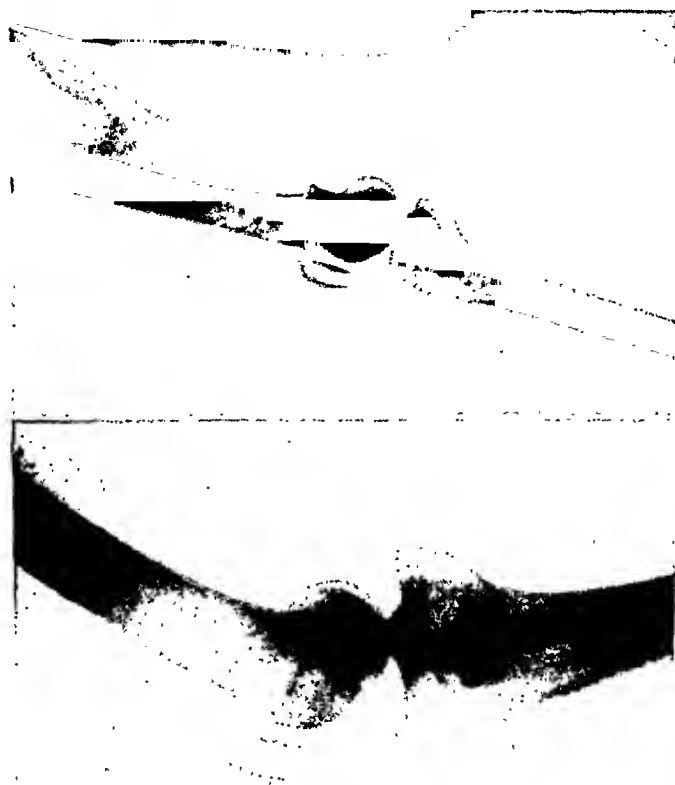
FIG. 16. Fixed flexion and supracondylar osteotomy.

result evaluation in 210 cases on whom 554 operations were done. (Chart 1.)

CHART II
EQUINUS DEFORMITY OF FOOT

	Operations	Good	Fair	Poor
Stretching of tendon of Achilles...............	31	1	4	26
Lengthening of tendon of Achilles...............	92	28	17	47
Resection of nerves to gastrocnemius...........	37	28	3	6
Resection of nerves to gastrocnemius and lengthening of tendon of Achilles	17	16	0	1
Posterior bone block (Wagner)..................	32	28	3	1
Total.................	209			

For equinus deformity of the foot, there were 209 operations. (Chart II.) It will be

because the influence has not been altered. In lengthening of the tendo Achilles, the same situation exists unless the tendon is lengthened sufficiently to weaken the muscle by atrophy of disuse. Over half have recurred and, of these, eight cases of calcaneous deformity developed from too great lengthening. This procedure is indicated when there is contracture but is best accompanied by Stoffel operation on nerves to gastrocnemius. The procedure now used is a 2 inch transverse incision (Figs. 1 and 2) made in the popliteal space at the level of the knee joint. The fascia is split longitudinally and the tibial nerve isolated. The medial sural cutaneal nerve is the first branch encountered posteriorly. Just below and to each side of this will be seen the branches to the heads of the gastrocnemius. These are cut and avulsed. The wound is closed anatomically.

In cases of severe spastic equinus or when there has been recurrence after nerve resection, a posterior bone block seems to

For adduction of the hip, there were 123 operations. (Chart III.) When the obturator nerve was resected with tenotomy of the
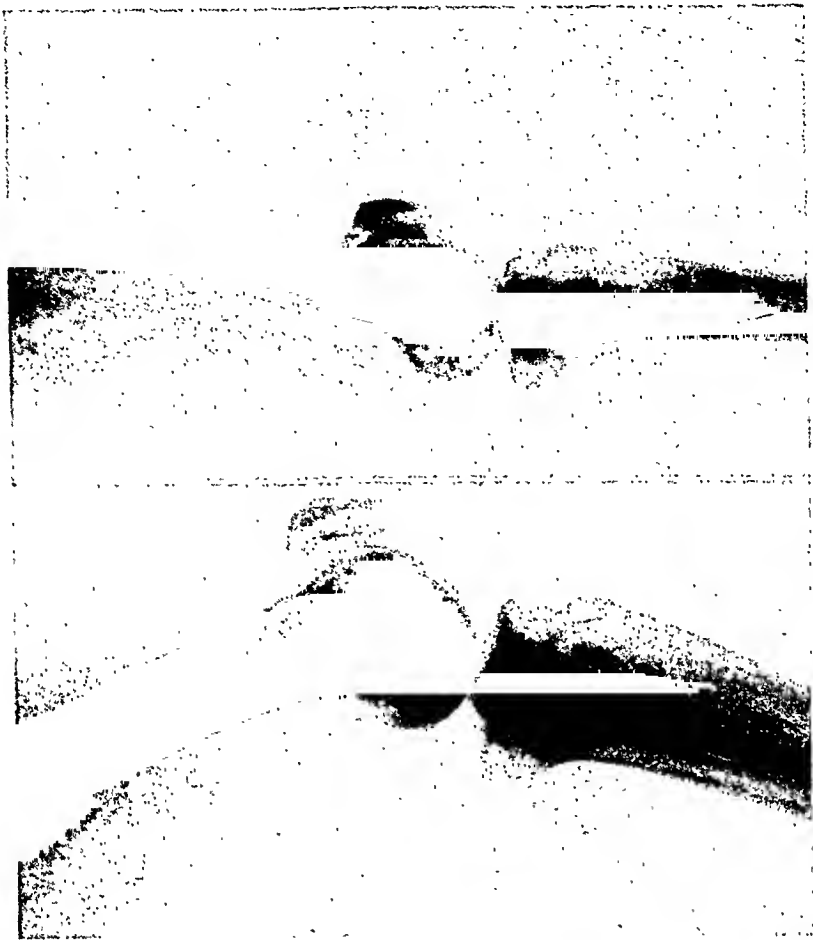
Fig. 17. Fixed flexion and supracondylar osteotomy.

be the ideal operation. There were thirty-two cases of the Wagner type (Figs. 3 to 8), with only one failure, being in a child of

adductor longus muscle, the majority were successful. Here again, it should be noticed that stretching is unsound. The usual procedure of obturator nerve resection is a 2 inch incision, starting at the pubis, lateral to the adductor longus, or a transverse incision a thumb's breadth below the pubis. The fascia is incised longitudinally, exposing the tendon of the adductor longus. The latter is cut at its attachment and allowed to contract. By blunt dissection, the lateral border of the adductor brevis is located. At this point, the branches of the anterior ramus will be found. These are clamped and cut. By blunt dissection, this is followed upward to the obturator foramen. Usually, the posterior ramus will be encountered leading from it, going posterior to the adductor brevis. If not, it may be found slightly deeper piercing the obturator externus. The distal por-

CHART III
ADDUCTION DEFORMITY OF LEG

	Operations	Good	Fair	Poor
Resection of obturator nerve and adductor longus tenotomy..........	108	87	7	14
Adductor longus and brevis tenotomy..............	6	0	2	4
Stripping of all adductors..	2	2	0	0
Stretching of adductors and application of plaster spica................	7	0	2	5
Total.............	123			

6 years where absorption of the bone block occurred.

tions may be avulsed and the wound closed anatomically. Plaster spicas are applied with the legs in abduction.

unusually high, the Chandler operation was done (Fig. 18), all of which gave a good result.
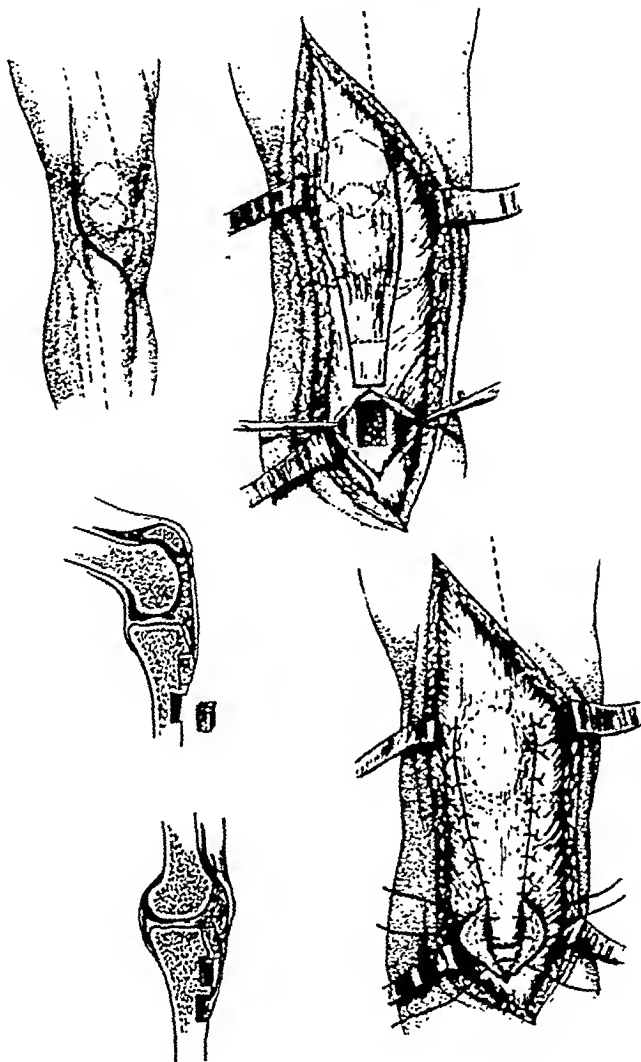
FIG. 18. Chandler operation—transplant of tibial tuberosity.

In cases of flexion deformity of the knee, there were eighty-one operations. (Chart IV.) The most common was biceps transplant to the patella. The majority of these improved the patients, but most were still unable completely to extend the knee by active power. When there was a fixed deformity of the knee which could not be easily corrected by stretching, a supracondylar osteotomy was the most effective and simplest manner of correction. Stretching of the knee alone was again a failure, as the imbalance still persisted. In a few cases, where it seemed the patella was

For deformities of the foot (Chart v), it will be noticed that correction by bony operation was the most successful operation, although correction of imbalance by transplantation of the anterior tibial tendon to the outer foot for varus gave good results. For the correction of calcaneus following lengthening of tendon of Achilles, astragalectomy gave surprisingly good correction.

Flexion deformity of the wrist (Chart VI) has been mainly corrected by attempting to regain muscle balance and that by means of transplanting flexor muscles to

the extensors of the wrist and fingers. (Fig. 24.) The majority of these improved

CHART IV
FLEXION DEFORMITY OF THE KNEE

	Operations	Good	Fair	Poor
Biceps transplant to patella	35	7	22	6
Semitendinosus to patella..	4	1	1	2
Semitendinosus and biceps to patella.............	2	1	1	0
Supracondylar osteotomy...	3	3	0	0
Stretching................	20	0	3	17
Transplantation of patellar tendon downward (Chandler).............	.7	7	0	0
Stripping ischial tuberosity	1	0	0	1
Lengthening biceps and semimembranosus with section of semitendinosus	9	4	5	0
Total.................	81			

the patients both in function and cosmetically. The latter alone, especially in girls, made the operation worth while. The very

CHART V
DEFORMITIES OF THE FOOT

	Operations	Good	Fair	Poor
Varus				
Hoke arthrodesis and transplantation of tibialis anticus to outer foot...............	6	6	0	0
Transplantation of tibialis anticus to outer foot...............	7	6	0	1
Hoke arthrodesis........	12	10	1	1
Stretching.............	5	1	2	2
Astragalectomy.........	2	1	1	0
Equinocavus				
Fasciotomy (Steindler)..	4	0	0	4
Hoke arthrodesis and lengthening of tibialis anticus.............	7	6	0	1
Lambrinudi arthrodesis..	2	2	0	0
Calcaneus				
(following lengthening tendo Achilles) 8 cases				
Astragalectomy.........	4	2	2	0
Total.................	49			

best results were obtained by accompanying the transplant with arthrodesis of the

wrist. Arthrodesis of the wrist is a very difficult thing to do because of the extreme

CHART VI
FLEXION DEFORMITY OF WRIST

	Operations	Good	Fair	Poor
Stretching of wrist........	12	0	1	11
Transplantation of both flexor carpi tendons to extensors of fingers......	16	5	10	1
Transplantation of ulna flexor carpi tendon to extensors of fingers........	7	2	4	1
Arthrodesis..............	8	2	2	4
Arthrodesis and tendon transplant.............	3	2	1	0
Lengthening of flexor tendons...................	2	0	1	1
Stoffel operation to flexors of wrist and fingers......	1	1	0	0
Total.................	49			

muscle pull. The majority had recurrence of deformity. It is now felt that an extensive fusion of the wrist with a graft is necessary in most cases. (Figs. 25 and 27.) Stretching of the wrist and fingers alone has been worthless, as has been lengthening of the flexor tendons. In regard to Stoffel's operation in the arm and forearm, only two cases were done with great improvement. It is felt that more of these should be done than we have here.

For pronation deformity, the Tubby operation has been successful. (Chart VII.) Whether or not this may be considered a functioning transplant, one cannot be certain. There have been recent operative cases not included, in which the pronator teres was merely sectioned with good results to date.

One patient with very severe spasmodic torticollis was admitted. He was unable to get about because of violent contraction of the trapezius. Section of the spinal accessory and muscular branches of the third and fourth cervical motor branches resulted in marked improvement. The patient has been able to go about with a brace to hold his head erect and is gradually

FIG. 19. Spastic flexion of knees and biceps transplant, right.

FIG. 20. Case of Figure 19, Chandler operation, left.

developing muscle power on the unaffected side sufficient to hold his head up for a short time.

CHART VII
PRONATION DEFORMITY

	Operations	Good	Fair	Poor
Pronator teres transplant (Tubby).............	4	3	1	0

DEFORMITY OF HAND

	Operations	Good	Fair	Poor
Flexion of thumb Transplantation of extensor indicis to extensor pollicis............	1	1	0	0
Adduction of thumb Section of adductor pollicis................	1	1	0	0
Adduction of thumb with spasm of interossei muscles Section of deep motor branch of ulnar nerve at wrist.............	1	1	0	0

SPASM OF NECK

	Operations	Good	Fair	Poor
Section spinal accessory nerve and third and fourth cervical roots.....	1	0	1	0

Hip flexion deformity has not been corrected as frequently as it is seen. (Chart VIII.) Stretching was of no use in most cases. When the deformity was corrected

CHART VIII
DEFORMITIES OF HIP

	Operations	Good	Fair	Poor
Flexion				
Stretching..............	7	1	0	6
Soutter operation.......	8	6	0	2
Subluxation				
Reconstruction of acetabulum............	2	1	1	0
Total.................	17			

by the Soutter operation, the results were much better. This operation seems to be

of more value in spastics than in poliomyelitis as it tends to equalize muscle balance.

CHART IX
DEFORMITIES OF TOES

	Operations	Good	Fair	Poor
Hyperextension of great toe Transplantation extensor hallucis longus with fusion of interphalangeal joint..........	3	3	0	0
Flexion of great toe Tenodesis of extensor tendon..............	1	1	0	0
Fusion of metatarsophalangeal joint..........	1	0	0	1
Hammer toe Fusion of interphalangeal joint................	3	0	0	3
Claw toes Transplantation extensor tendons to metatarsals	1	0	0	1
Stretching toes..........	1	0	0	1

Deformities of the toes are frequently seen and are very troublesome. (Chart IX.) Transplantation of tendons and relief of

CHART X
SYMPATHETIC RAMISECTION

	Operations	Good	Fair	Poor
Lumbar.................	3	0	0	3
Cervical.................	5	0	1	4
Done at Ruptured and Crippled by Dr. Royle in 1924.................	2	0	0	2

spasm by Stoffel operation offer the best means of treatment. Fusion of inter-

CHART XI
DEATHS

Posterior bone block.............................	1
Obturator nerve resection.........................	2
Lengthening of tendon of Achilles.................	1
Biceps transplant................................	1
Sympathetic ramisection..........................	1
Total..	6

phalangeal joints in small toes has always been a failure because of the inability to

maintain the position in the presence of such spasm.

Several years ago, during the height of

be noticed by the patient alone. All the patients felt increased warmth in the parts, but this was only temporary also.

FIG. 21. Spastic flexion of knees with bilateral Chandler operation.

FIG. 22. Postoperative x-ray of patient in Figure 21.

popularity, sympathetic ramisection was done in a few cases. (Chart x.) Permanent relief was given to only one and that could

Two patients operated on by Dr. Royle in 1924 also had no improvement.

Out of a total of 554 operations done on 210 patients, there were six deaths. (Chart XI.) One died of postoperative pneumonia and one of scarlet fever arising shortly after operation. Four others died from four to eight days after operation, after a sudden marked rise in temperature, one going as high as 110 degrees. It is felt that there is a disturbance in the heat regulating centers, as one of the patients who died had a similar reaction after a previous operation, but had recovered. Also it has been noted that many spastic children have an acetone urine for several days after operation in spite of good postoperative care.

SUMMARY

From this review of the literature and end result study, the conclusion has been reached that the treatment of cerebrospinal spastic paralysis, as a whole, has not changed a great deal. From time to

time, new procedures have been added, each of which has offered something, but nothing specific. It has given the impres-

tion of the favorable cases and commitment of the others.

Reëducation has been definitely accepted
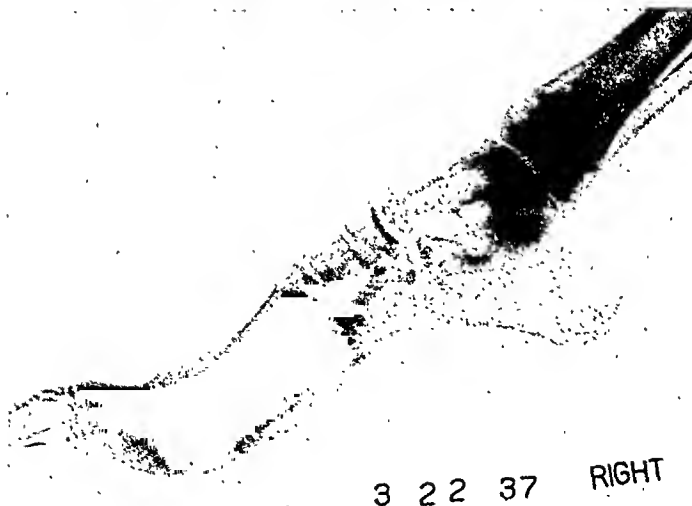
FIG. 23. Fixed equinus deformity.

sion that these patients have become a great problem to society as well as to medicine, and that greater interest is being taken to classify them into groups according to the prognosis for improvement. Various communities are organizing groups and clinics for their examination and treatment, and institutions are being established for the treatment and educa-

as a means of rehabilitation of these patients accompanied by surgical interference as an adjunct, or to correct disabilities or deformities which could not be aided in a conservative way.

The operation of posterior root section of Foerster, though reported as successful by many writers, is not generally done, and its permanent results are doubtful. It is a

serious operation with a definite mortality, and should only be considered in the very severe cases of spasticity which have marked sensory irritability.

tion. In the milder cases, these operations have given complete relief and removed the disability.

There is no doubt that decompression

A   B

C

FIG. 24. Case of Figure 23, Lambrinudi operation.

Procedures done on the peripheral nerves according to Stoffel and modifications have proved with time to be of great value and are easily done by good surgical technicians. The relief of marked spasm causing imbalance of power at a joint has been a tremendous aid to muscle reëduca-

operations have their place in the cases of children showing increased intracranial pressure which cannot be relieved by other methods, and in those children having localized meningeal hemorrhage at birth, to prevent subsequent brain damage. Of course, the diagnosis here will depend on

the alertness of the obstetrician. In the late cases, after the pathology has become static, the benefit is only slight. Many logic basis on which it is done is still uncertain. The few cases seen and reviewed were not benefited sufficiently or permanently,
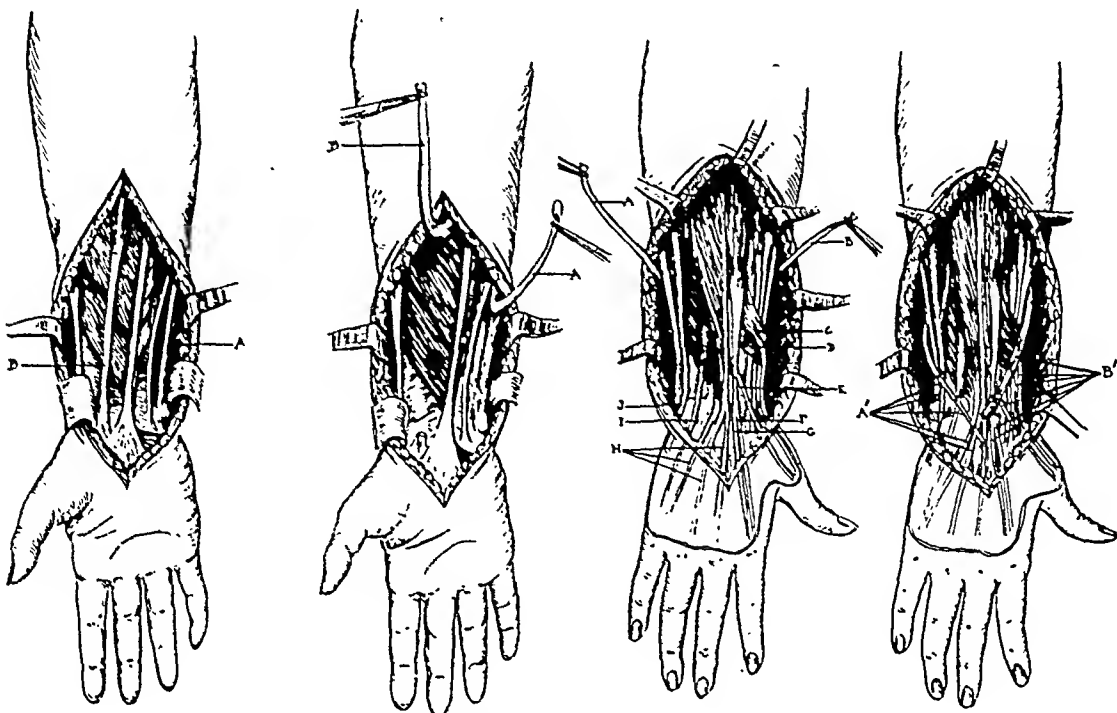
FIG. 25. Transplantation of wrist tendons.

operations have relieved patients of epileptiform seizures, which certainly make it worthwhile for the family if not for the and one cannot say the operation was worth doing. The patients were temporarily relieved and felt more comfortable for a
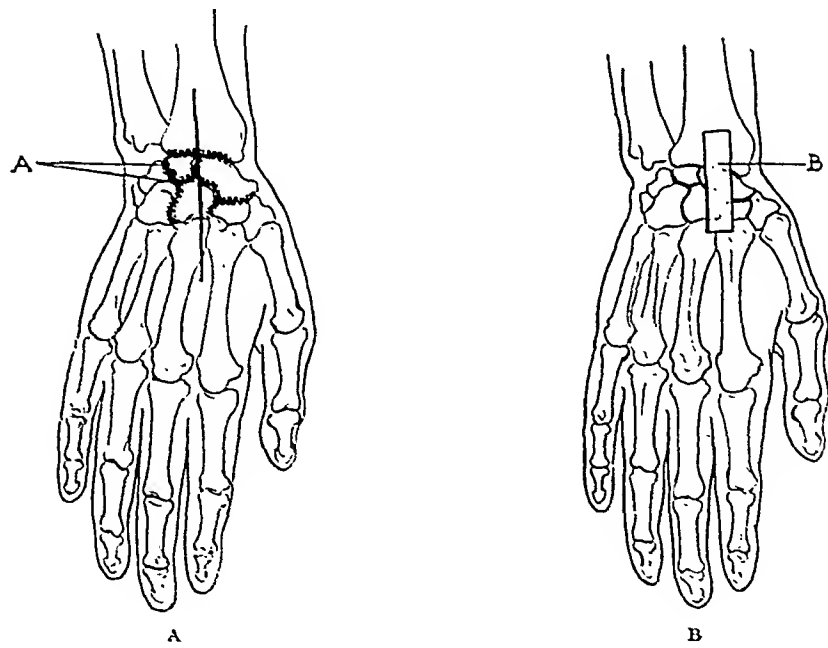
FIG. 26. Arthrodesis of the wrist.

patient, even though the spasticity remains the same afterward.

As for sympathetic ramisection, one hardly knows what to say because of the marked difference of opinion. The physio- few months. It is possible this could all have been brought about by increased circulation in the extremities. We all know that spastic patients feel freer and easier in a warm pool and most seem to do better

with muscle reëducation in the summer than the winter. It is a major surgical procedure with doubtful results, and so is not recommended.

FIG. 27. Arthrodesis of the wrist and flexor tendon transplant to extensors.

The treatment of athetosis by section of the extrapyramidal tracts is still in the experimental stage by the originator and others, so should not be evaluated.

It seems that the bulk of these cases will continue to fall into the hands of the orthopedic surgeons for relief of spasticity in individual muscle groups to prevent or correct deformity.

When the disability is equinus of the foot, it is concluded that muscle balance should be the goal. If this is not accomplished by nerve section, the foot must be held by a brace or splint, or recurrence must be expected in many cases. Frequently, muscle balance can be permanently obtained by the Stoffel operation on the nerve to both heads of the gastrocnemius. If there is contracture, stretching or lengthening of the tendon of Achilles must be done. The posterior bone block of Wagner type offers a splendid means of

preventing spastic contracture of calf muscles in older children and adults.

The correction of spastic adduction deformity of the legs can be well taken
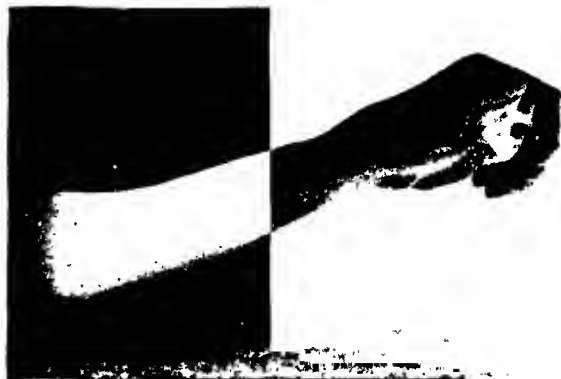
FIG. 28. Arthrodesis of the wrist.

care of by resection of both rami of the obturator nerve and section of the adductor longus. No ill results were seen.

A definite program should be followed when flexion deformity of the knee is present. At first the deformity should be corrected. If this cannot be done by stretching, then supracondylar osteotomy may be performed. When healed, usually
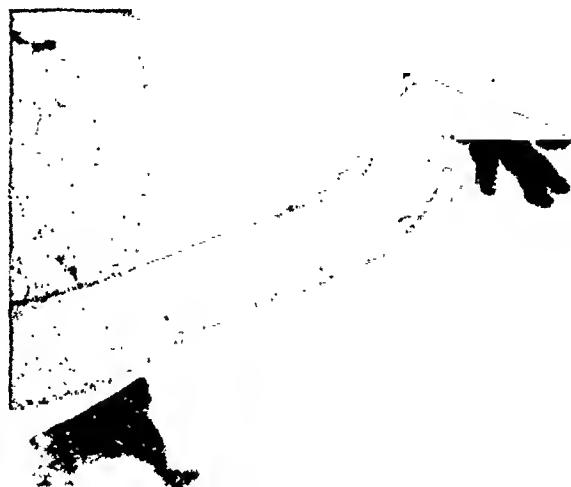
FIG. 29. Wrist flexor tendon transplant to extensors.

it will be noticed that the patella is higher than normal from an elongated patellar tendon. The Chandler operation has been successful for the correction of this. Later, if muscle balance is not present, trans-

plantation of the biceps muscle may be done to give added power to the extensors. Tenotomy, in addition, of the semiten-

Fig. 30. Transplantation of the extensor hallucis longus.

dinosus has produced no ill effects and given better balance.

When deformities of the foot are present, bony operations for correction and stabilization should be done. At the same time, any deforming spastic tendon should be transplanted, as is often the case of the anterior tibial.

The production of a good functioning hand by any procedure in spastics is only occasional, although marked improvement is possible. In cases where the fingers function fairly well but the wrist is in marked flexion, an arthrodesis may give tremendous improvement. The latter is difficult to obtain, and a thorough operation with bone graft is usually necessary. Transplantation of the flexor tendons of the wrist to the extensors of the fingers has given fair results. A combination of arthrodesis and tendon transplant has been quite successful. Stoffel operations are recommended on nerves to flexors of the fingers for release of spasm.

In the majority of these cases with wrist deformity, there is also pronation. The

Jones operation is recommended by Wilson, as it releases pronation and gives added strength to the extensors. The

Tubby operation has been successful for pronation but simple tenotomy of the pronator teres may be as effective.

Flexion deformity of the hips is a frequent condition, but, unless marked, is not disabling. The Soutter operation has properly taken care of the condition. Stretching may be helpful in mild cases.

In regard to the toes, hyperextension of the great toe is frequently seen and not much has ever been done about it. Transplantation of the extensor hallucis longus tendon to the neck of the first metatarsal has completely relieved the patients. Other operations on the toes have not been successful, so it is felt that Stoffel operation on the nerves to the toe flexors, though not frequently done, would be of great value.

The authors wish to stress the proper protection of limbs by braces or splints over a sufficiently long period after operation has been done, so that patients may become adjusted to their new positions and obtain reëducation of transplanted muscles.

CONCLUSIONS

1. A postoperative end result study has been made of 210 patients with cerebrospinal spastic paralysis.

2. An evaluation of 554 operations done on these patients was made.

3. For equinus deformity of the foot, Stoffel operation on the nerves to the gastrocnemius with heel cord lengthening when necessary was the best method of obtaining muscle balance. This balance should be maintained by muscle training, application of a brace, or by a posterior bone block of Wagner type.

4. Adduction deformity of the legs was best relieved by complete resection of the obturator nerve and section of adductor longus.

5. For flexion of the knee, correction of fixed deformity is first necessary by stretching or supracondylar osteotomy. Following this, reëstablishment of normal leverage of the patella is obtained by Chandler operation. If, after muscle training, the quadriceps is still weak, this should be reinforced by biceps transplant. Stoffel operation on nerves to remaining hamstrings or section of semitendinosus may be done.

6. Deformities of the foot are best corrected by bony operation and stabilization. Removal or transplantation of deforming muscles should be done.

7. For simple flexion deformity of the wrist, arthrodesis is an excellent procedure. When the fingers are involved, transplantation of the flexors of the wrist to the extensors of the fingers with arthrodesis of the wrist has given fair results. Stoffel operation on nerves to finger flexors is beneficial to relieve extreme spasm.

8. Pronation deformity may be relieved by Tubby operation or section of pronator teres.

9. Soutter operation offers the best method of correction of hip flexion.

10. Hyperextension of the great toe can be corrected by transplantation of the extensor hallucis longus to the neck of the metatarsal with fusion of the interphalangeal joint.

11. Sympathetic ramisection has offered no permanent relief to nine patients out of ten.

12. A certain number of cerebrospastic patients will die postoperatively from some unknown cause, possibly disarrangement of the heat regulating centers.

13. All patients should have an observation period of muscle training before operation and adequate training afterward, for rehabilitation.

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(Bo.B.) = Bookshelf Browsing; (E.) = Editorial